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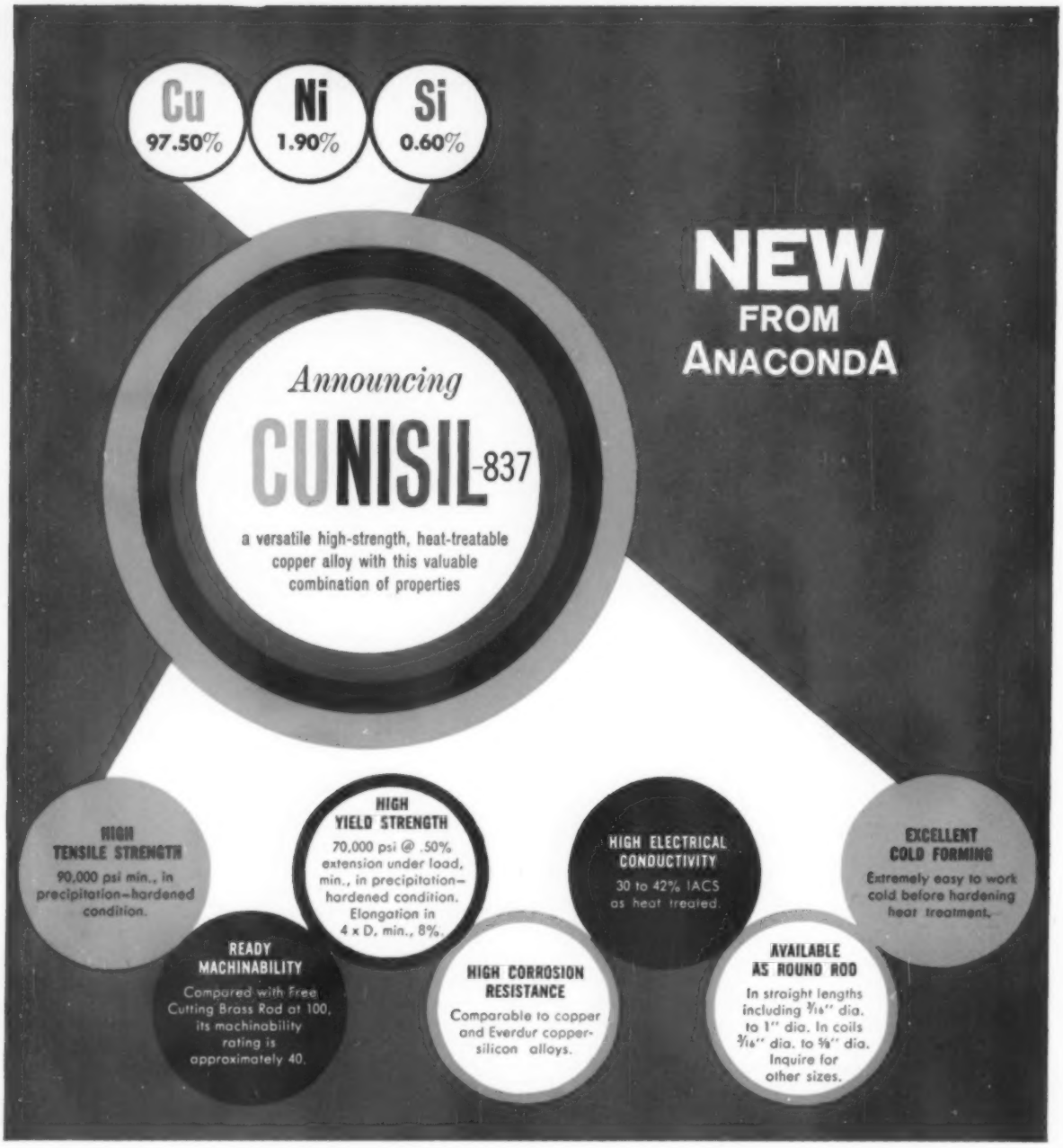
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*Aluminum Alloys for Processing Equipment*
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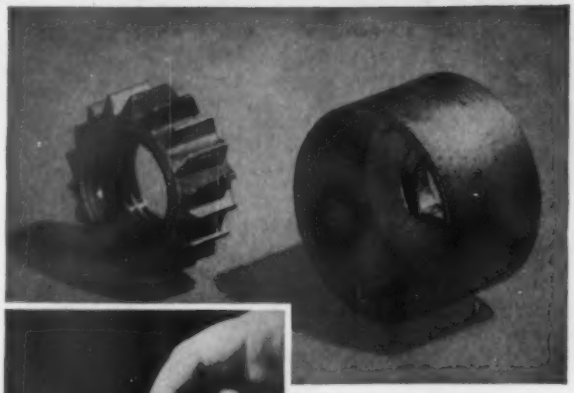

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These precision parts for the HALSEY W. TAYLOR COMPANY water fountain valve were formerly made on a screw machine. The handle-adjusting nut (left) was cut from pinion stock and the lock sleeve (right) required broaching for nut engagement—all expensive operations leading to high parts cost.

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# Why metals corrode...and how you can prevent it

The basic cause of corrosion is the instability of metals in their refined state. Metals tend to revert to their natural states through the processes of corrosion. For example, when you analyze rust, you will find it is iron oxide. When you analyze natural iron ore, you find it, too, is iron oxide. Six forms of corrosion which can attack the equipment you design are:

1. General tarnishing or rusting with occasional perforations in highly affected areas.

2. Highly localized attack by pitting.

3. Cracking induced by a combination of stress and corrosion.

4. Corrosion confined to crevices, under gaskets, or washers, or in sockets.

5. Corrosion of one of an alloy's constituents leaving a weak residue.

6. Corrosion near the junction of two different metals.

In all of the six forms of corrosion mentioned above, corrosion has the same basic mechanism. It's similar to the electrochemical action in a dry cell.

**The electrolyte** in the dry cell corresponds to the corrosive media, which may be anything from the moisture in the air to the strongest alkali or acid.

**The plates of the battery** correspond to the metal involved in corrosion.

A potential difference between these metals or different areas on the same metal causes electricity to flow between them through the electrolyte and a metallic bridge or contact that completes the circuit.

At the anode, a destructive alteration or eating away of metal occurs when the positively charged atoms of metal detach from the solid surface and enter the solution as ions.

The corresponding negative charges, in the form of electrons, travel through the metal, through the metallic bridge, to the cathode.

**Briefly then, for corrosion to occur,** there must first be a difference in potential between the metals or areas on the same piece of metal so that electricity will flow between them. Next, a release of electrons at the anode and a formation of metal ions through disintegration of metal at the anode. At the cathode, there must be a simultaneous acceptance of electrons. Action at the anode cannot go on alone, nor can action at the cathode.

## CONTROLLING CORROSION

When corrosion occurs because of the differences in electrical potential of dissimilar metals, it is known as galvanic action. Differences in potential from point to point on a single metal surface causes corrosion known as local action.

**When you plan against galvanic corrosion** it is essential to know which metal in the couple will suffer accelerated corrosion . . . will act as the anode in the corrosion reaction.

The galvanic series table shown below can supply this information. In any couple, the metal near the top of this series will be the anode and suffer accelerated corrosion in a galvanic couple. The one nearer the bottom will be the cathode and remain free from attack or may corrode at a much slower rate.

### GALVANIC SERIES TABLE

Magnesium
Magnesium alloys
•
Zinc
•
Aluminum 25
•
Cadmium
•
Aluminum 17ST
•
Steel or Iron, Cast Iron
•
Chromium-iron (active)
•
Ni-Resist
•
18-8 Stainless (active)
18-8-3 Stainless (active)
•
Lead-tin solders
Lead, Tin
•
Nickel (active)
Inconel (active)
•
Brasses, Copper, Bronzes
Copper-nickel alloys, Monel
•
Silver solder
•
Nickel (passive)
Inconel (passive)
•
Chromium-iron (passive)
18-8 Stainless (passive)
18-8-3 Stainless (passive)
•
Silver
•
Graphite, Gold, Platinum

## HOW TO USE THE CHART

Notice how the metals are grouped in the galvanic series table. Any metal in one group can be safely used with any other metal in the same group. However, when you start mixing metals from different groups, you may run into serious galvanic corrosion of the metal higher on the list. And the further apart these metals are listed, the worse this corrosion may be.

But, if you have to mix metals, pay particular attention to the electrical contact between them. Eliminate any metallic bridges or contacts of metal to metal that will permit the flow of electrons through them. You can do this by separating the metals physically, or by using insulation or protective coatings. Another factor is the relative areas of the metals in contact with each other. Parts having the smaller area should be of a metal with a lower listing on the galvanic series table than the metal used for the larger area.

**When you plan against local action,** remember that the corrosion process is galvanic: Electrons move from one point in the metal to another. One of the easiest ways to prevent local action is to use a metal with little or no impurity. When alloys are involved, make sure the constituents are closely listed in the galvanic series table. Local action may also be stopped by the use of protective coatings, which shield the metal from the corrosive media. Environment must also be considered, for its nature may be an important factor in either promoting or restricting corrosion.

## TECHNICAL ASSISTANCE

As you can see, many factors are involved in both local and galvanic action. That's why it's best to bring your metal problem to Inco's Corrosion Engineering Service. Available data will be furnished wherever possible . . . tests will be made where needed. Inco's Corrosion Engineering Service will be glad to apply principles of corrosion control to your specific problem.

## LITERATURE

The publications listed below will provide more detailed information on how you can combat corrosion by using nickel-containing metals.

| Publication Number | Name |
|---|---|
| A232 | Corrosion Problems in Nuclear Reactor Power Stations |
| A59 | Factors of Importance in the Atmospheric Corrosion Testing of Low-Alloy Steels |
| A62 | A Theory of the Mechanism of Rusting of Low-Alloy Steel in the Atmosphere |
| A137 | Corrosion by Some Organic Acids and Related Compounds |
| A144 | Some Observations of the Potentials of Stainless Steels in Flowing Sea Water |

A complete list of the 187 Inco publications and technical bulletins on nickel-containing metals can be obtained by writing for "List A", to:

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# What's new IN MATERIALS

...AT A GLANCE

**The trend toward increasing use of aluminum in automobiles** may be accelerated by three recent developments: 1) a new series of heat treatable alloys for fabrication into bumpers, 2) a duplex nickel-chromium plating process for protecting the bumpers against the corrosive action of road splash, and 3) a high purity, non-heat treatable alloy for fabrication into interior and exterior trim. The aluminum bumpers are expected to be competitive in price with steel bumpers. Composition of the new alloys has not been disclosed. (More details in a forthcoming issue.)

Sources: Kaiser Aluminum & Chemical Corp., 300 Lakeside Dr., Oakland 12, Calif. (1, 2), and Reynolds Metals Co., Richmond 18, Va. (3).

**A new series of heat resistant fiberglass honeycomb core materials** are described as the "strongest and lightest plastics honeycomb cores ever produced." The cores are made of a phenolic resin-impregnated fiberglass cloth which is coated with a heat resistant phenolic compound. The series includes six different cores ranging in density from 2 to 15 lb per cu ft.

Source: Hexcel Products Inc., 2332 4th St., Berkeley, Calif.

**Baked enamel films containing a new thermosetting acrylic** are said to have the following properties: 1) high hardness, 2) excellent gloss, 3) excellent retention of color and gloss with age, 4) excellent resistance to stains, grease and solvents, 5) exceptional resistance to detergent and soap solutions, and 6) very good resistance to deformation at elevated temperatures.

Source: Rohm & Haas Co., Resinous Products Div., Washington Square, Philadelphia 5.

**A new fluorocarbon plastic—polyvinylidene fluoride**—features excellent resistance to weathering, chemicals and heat, combined with good mechanical strength. The molded resin has 6000 psi tensile strength, 2.0 x $10^5$ psi flexural modulus, 10,000 psi compressive strength, and 3 ft-lb-per-in. notched impact strength. Maximum continuous service temperature is reported to be about 300 F. The resin, not yet available, will probably sell for about $3 per lb.

Source: Pennsalt Chemicals Corp., 3 Penn Center, Philadelphia 2.

**An improved electron tube anode material—carbon-coated steel**—is available in limited quantities. Tests show the new material has emissivity comparable to that of gas carbonized nickel-clad steel with one-half to one-third the gas content. Power dissipation is similar to that of aluminum-clad low alloy steel anode material, and density is twice that of gas carbonized materials. The carbon-coated steel is expected to compete in price with presently used anode materials.

Source: Metals & Controls Div., Texas Instruments Inc., 34 Forest St., Attleboro, Mass.

**Irradiated polyethylene film now available** may compete with saran, polyester and cellophane films for shrink-packaging of fruits, meat, poultry, vegetables and bakery products. Reason: the new film has excellent shrink strength, yet costs only 3¢ per 1000 sq in. of 1-mil film, compared to 4¢ for saran, 4.36¢ for polyester and 2.7 to 3.3¢ for cellophane. Irradiation increases the strength of the film more than 500% and makes it possible to stretch the material more than 200% in both

directions. Stretched film immediately shrinks in all directions upon exposure to hot air or hot water until it returns to its original size. (More details next month.)
Source: W. R. Grace & Co., Cryovac Div., 3 Hanover Sq., New York 4.

**A heat resistant epoxy electrical tape,** said to be the first such tape available, has a backing of fully cured, flexible, 100% solids epoxy resin reinforced with glass cloth. The pressure sensitive tape is recommended for Class F (310 F) electrical applications.
Source: Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

**An improved 2011-T3 aluminum screw machine bar stock** is said to have substantially better machining qualities, and a brighter and cleaner surface, than conventional 2011-T3 alloy. A test program conducted by the producer showed that the stock extended cutting tool life and made possible smaller and finer chips in screw machine operations. Composition has not been disclosed.
Source: W. J. Lawler, Kaiser Aluminum & Chemical Corp., 300 Lakeside Dr., Oakland 12, Calif.

**Fiberglass-reinforced concrete parts for structural applications** are possible by using an epoxy resin to bind glass fibers to themselves and to concrete, recent research indicates. The epoxy binder, which hardens during the setting of the concrete, protects the glass fibers against the high alkalinity of the concrete.
Source: S. Goldfein, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va.

**A new high strength, low alloy steel** for transportation, construction and industrial equipment is available in the form of hot rolled sheet and strip. The material (composition not revealed) meets requirements of SAE 950 and ASTM A242-55. It can be welded without pre- or post-heating treatments.
Source: Armco Steel Corp., Middletown, Ohio.

**Vinyl dispersion coatings that can be applied to textured metals** successfully reproducing the texture of the base metal are now on the market. The coatings, which can also be applied to smooth metal surfaces, have high abrasion resistance and are being used in a pioneer mass production application—domestic dishwasher interiors.
Source: Metal & Thermit Corp., Coatings Div., Rahway, N. J.

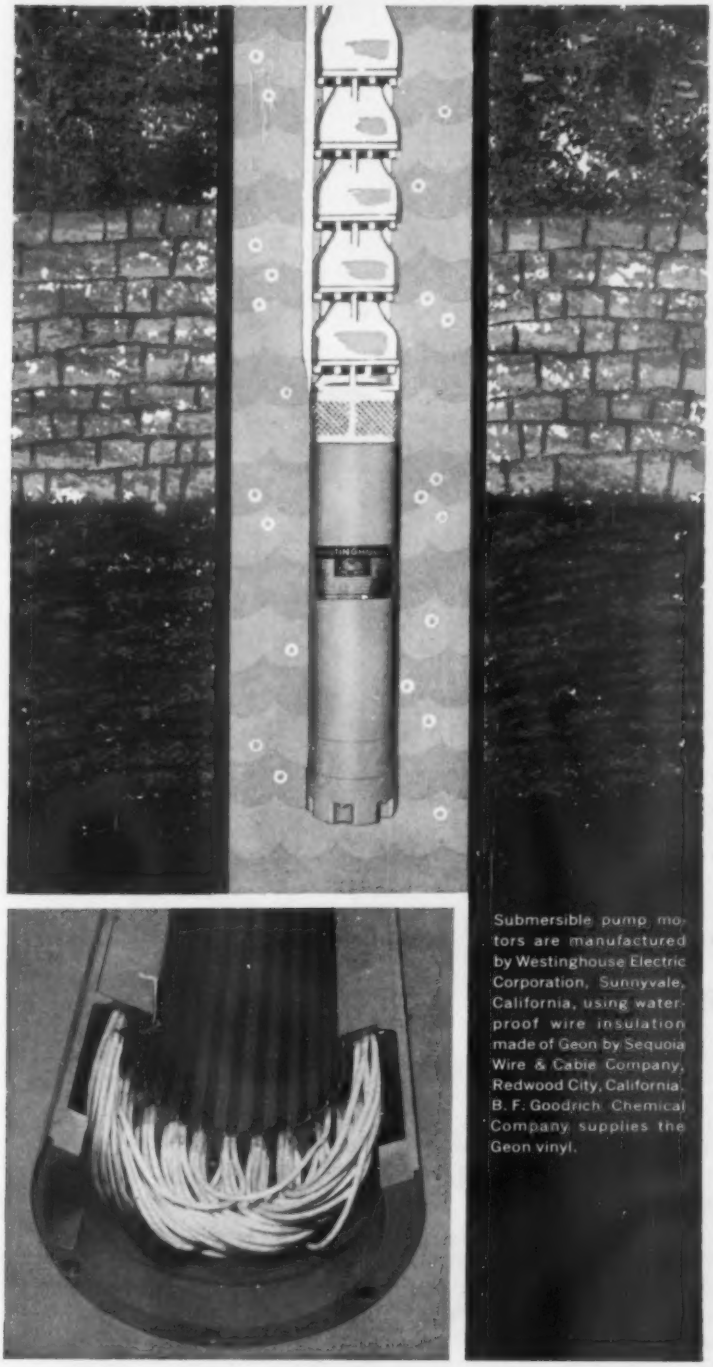
**A fused quartz ceramic foam for 2500 F service** has good electrical properties, and can be bonded to itself and to other ceramics. The new material has a unicellular foam structure and weighs approximately 12 lb per cu ft. It is particularly useful in microwave devices.
Source: Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.

**An improved general purpose styrene** has been developed. According to the developer, parts made of the resin meet or exceed current toughness standards for general purpose resins. The new resin is also said to have a higher heat distortion point (210 F at 264 psi for annealed specimens) than that of other general purpose grades. It sells for 21½¢ per lb.
Source: Dow Chemical Co., Midland, Mich.

**Turn to page 9 for more "What's New in Materials"**

*Another new development using*

# B.F.Goodrich Chemical *raw materials*





Submersible pump motors are manufactured by Westinghouse Electric Corporation, Sunnyvale, California, using waterproof wire insulation made of Geon by Sequoia Wire & Cable Company, Redwood City, California. B. F. Goodrich Chemical Company supplies the Geon vinyl.

## Problem of motor submersion solved with Geon insulation

This new motor operates under water using the water itself as a lubricant. Since the housing is water filled and "breathes" well water, its operation depends on the insulation of Geon.

Geon met tough requirements. The manufacturer says that many materials were tested to find one that would stay waterproof indefinitely and also have enough mechanical strength to stand up under the winding process and under flexing imposed in starting.

A test motor was submerged under 400 feet of head for six months and subjected to frequent starting and operation. At the end of the test, the Geon insulation showed no signs of deterioration. Geon also eliminates need for thick and dense coatings over end turns—eliminating a cause of trapped heat and premature failure.

Here's another example of the way that Geon vinyls open new markets, or improve present applications. For more information, write Dept. GV-2, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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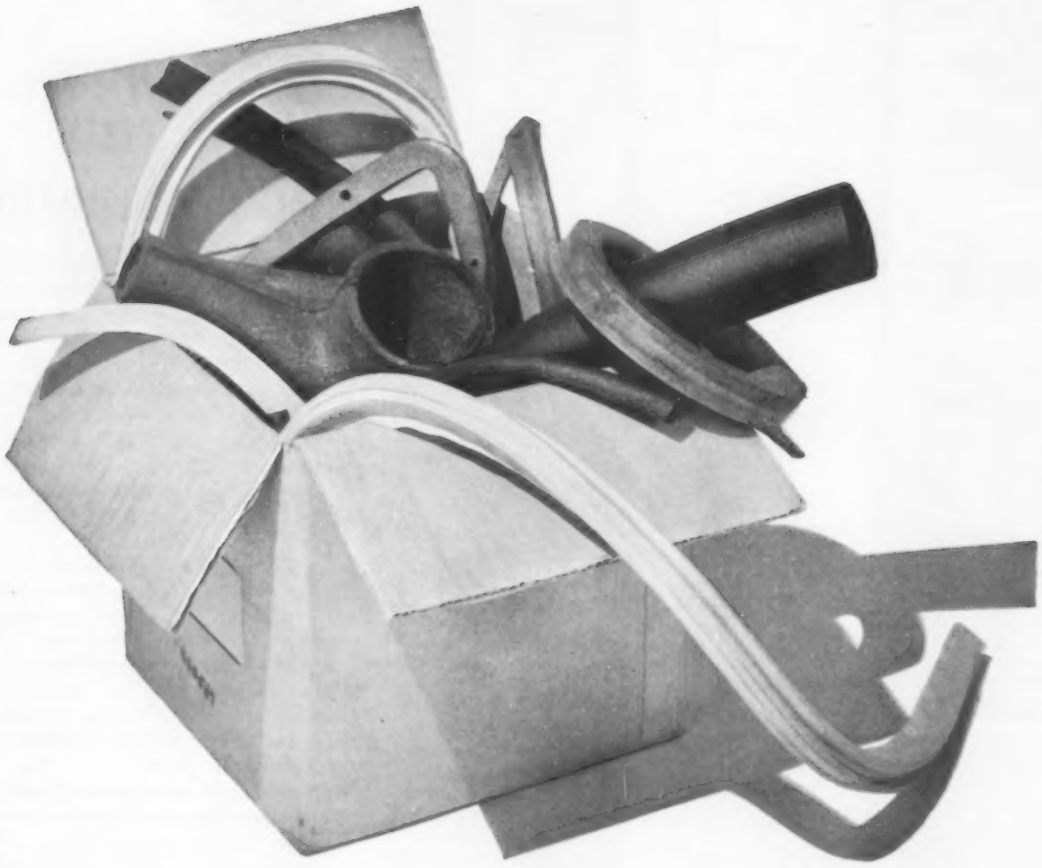

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# Hard Anodic Coating for Aluminum

*is applied at rate of 1 mil per min*

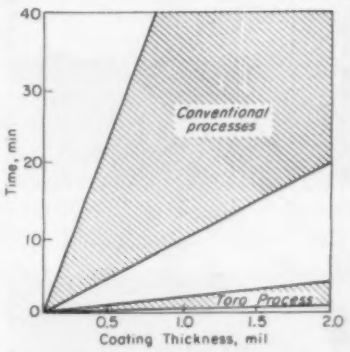
■ A new hard anodizing process developed by Toro Mfg. Corp., 3042 Snelling Ave., Minneapolis 6, Minn., is said to be 10 to 50 times faster than conventional hard anodizing processes. Whereas regular processes take 10 to 50 min to build a 1-mil coating, the Toro process deposits the same coating in 1 min.

In addition to high speed, the process offers increased electrical efficiency, lower bath refrigeration requirements, and lighter product color. Mechanical properties of the coating are said to be equivalent to those of the four other hard coating processes—Martin, Sanford, Alumilite and Hardas.

Although the process is not yet ready for outside users, Toro is studying plans for making it commercially available.

**How it is applied**

Key to the speed of the new process is its ability to use very high current densities without burning the aluminum. Current density is 20 to 40 times greater than the 25 to 100 amp per sq ft commonly used.




***Comparative operating times** required to produce hard anodic coatings by the Toro process and conventional processes.*

Because of the high currents used, the process is limited by the heat conductivity and the surface-to-volume ratio of the part being treated. However, it can be used on most common products with the exception of aluminum foil and similar very thin products.

Since the electrolyte operates at a temperature of about 70 F it requires little refrigeration. Other electrolytes, in contrast, require expensive refrigeration since they must be kept at 25 to 50 F. Although electrolyte composition has not been disclosed it is said to be a common material.

**Properties**

In reporting on a comparative study, Armour Research Foundation states that the Toro coating and conventional hard coatings have essentially the same hardness and density, abrasion and corrosion resistance, frictional properties and electrical resistance. The Toro coating is light in color and ranges from a silver gray to a medium gray, as contrasted with the dark gray and black of other hard coatings. A wide range of colors can be obtained by dyeing the coating.

**Applications**

Although the Toro coating was originally developed to improve the hardness of grass-cutting reels it can be applied to many other aluminum products. Proposed applications include helicopter blades, pistons, gears, kitchen utensils, and automotive and architectural products.

**For more information, circle No. 600**

# A Boron Stainless Steel with Better Toughness, Corrosion Resistance

■ High neutron absorption and excellent mechanical properties are combined in a new type 304-base stainless steel containing up to 2% boron-10 isotope.

The new alloy, available from Carpenter Steel Co., Reading, Pa., is an improvement over type 304 containing natural boron, and will be useful for control rods, burnable poison and shielding for nuclear reactors. It offers improved design flexibility and at the same time promises to increase safety and reduce maintenance costs of nuclear power plants.

Control rods made of solid boron stainless steel rather than composite units containing boron carbide meet the latest design requirements in that they eliminate the sticking and binding of control rods that used to occur with the older boron carbide systems.

**What does boron do?**

As the boron content in steel is increased, tensile strength, yield strength and hardness increase (Fig 1 and 2). Ductility (Fig 3), impact strength and corrosion resistance decrease. Ordinarily, up

to 2% natural boron must be added to give the steel a high enough thermal-neutron-absorption cross section to function as a control rod, etc. This amount of boron cannot be added, however, without sacrificing important engineering properties.

**Why boron-10?**

By adding a much smaller amount of enriched boron (0.2% boron-10 isotope) it is possible to obtain mechanical properties and corrosion resistance that are almost as good as those of the basic type 304 alloy. Although considerably less boron is added, there is no loss in nuclear properties.

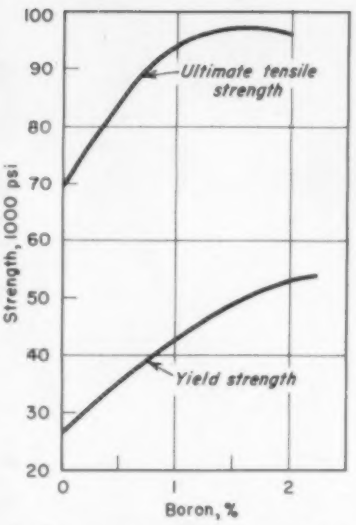
If an application requires greater neutron absorption than is obtainable with 2% natural boron, up to 2% boron-10 may be added to the alloy. In such a case, mechanical properties are naturally poorer than they would be at a lower boron-10 level.

The secret to performance lies in separating and properly concentrating the two boron isotopes, boron-10 and boron-11. The only apparent differences between the two are in nuclear properties. Natural boron is a mixture of the two, 18.4% boron-10 and 81.6% boron-11. Both absorb neutrons, but boron-10 has higher efficiency. The absorption cross section for boron-10 is 4020 barns; for boron-11 it is 0.05 barns.

Thus, for the new alloy, Carpenter uses an enriched boron additive containing a higher concentration of boron-10.

**Corrosion resistance**

This alloy retains the general corrosion resistance of type 304 stainless, although susceptibility to intergranular attack increases substantially as boron content increases. Addition of boron to type 304 lowers resistance to boiling 65% nitric acid in the solution annealed condition. For full corrosion resistance, forgings must be heated to at least 1950 F and water quenched.

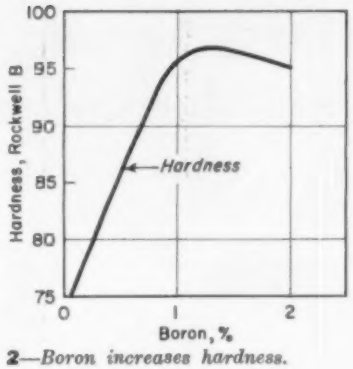



*1—Boron increases both yield and tensile strength.*

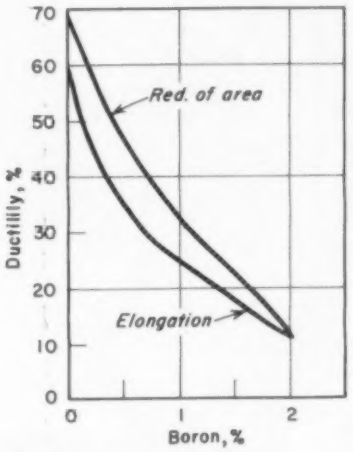
**Processing**

The steel is annealed by heating to 1850-2050 F and quenching in water. With 1% boron, the alloy has a Rockwell hardness of 96B. From 1 to 2% boron, hardness ranges between Rockwell 97B and 95B. Hardening is accomplished only by cold working.

Prior to hot working, the alloy should be heated uniformly to 2000-2200 F. Hot working temperature varies with boron content, and recommendations for specific forging temperatures should be requested from the mill. Hot working should be done above 1800 F. Because of the steel's higher red hardness, more power is required for a given reduction than for regular type 304. Forgings can be air cooled without danger of cracking.




*2—Boron increases hardness.*




*3—Boron lowers ductility.*

The alloy can be fabricated by cold working. With lower boron contents, cold workability approaches that of regular type 304. The steel also can be brazed and welded.

**Available forms**

Boronated type 304 is available in hot rolled bars, cold drawn bars, strip and wire.

**For more information, circle No. 601**

# Aluminum Structural Shapes Are Self-Damping

*Amplification factors as low as 3 to 10 reduce need for vibration isolators*

■ Self-damping aluminum structural shapes were recently announced by two companies. Damping is accomplished by incorporating a viscoelastic medium.

The new materials represent the first practical development which allows 1) all portions of the structure to act as load carrying members, and 2) materials and structures to be designed for near-optimum damping characteristics in the normal frequency range.

*How do the new materials work?* —Under impressed vibrations, the components, separated by a viscoelastic medium, slide relative to each other. Most of the resonant energy is absorbed in straining the viscoelastic layer in shear. As a result, the damped materials exhibit a resonant response only 5 to 10 times the excitation vibration; amplification in conventional materials may range from 60 to 300. The effect of built-in damping is shown in Fig 1.

**The two materials**

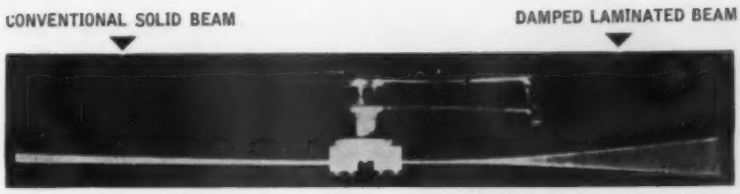
*Dyna-damp* — This material, manufactured by Lord Mfg. Co., Erie, Pa., uses BTR, a broad temperature range elastomer that maintains excellent damping and environmental resistance characteristics over the range –65 to 250 F. Dyna-damp structural sections have a resonant amplification of 3 to 5. Lord manufactures laminated panels as well as such structural sections as hats and angles (see Fig 2). The structurals are slotted beam sections with a layer of BTR elastomer bonded between.

*Rigidamp* — Barry Controls, Watertown 72, Mass., has developed materials that use an unspecified viscoelastic medium. Forms include sheets and thin rectangular section beams constructed as laminates separated by the viscoelastic damping medium.

Other Barry structural shapes such as I-beams, channels and angles are constructed on a cellular basis (see Fig 3). Each cell contains an insert separated from the cell walls by the viscoelastic medium. Patents have been applied for.

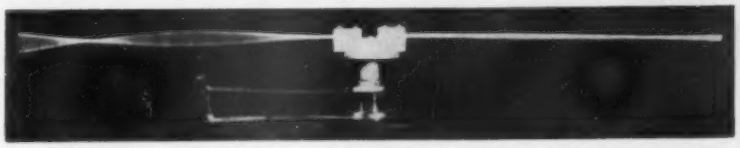
**Applications**

For current designs, both Rigidamp and Dyna-damp may be used to "fix" the resonant re-

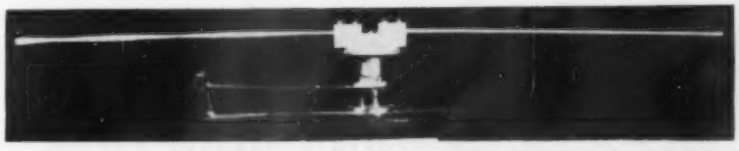



**1a**—*At 17 cps sinusoidal vibration input, conventional beam amplifies vibration by a factor exceeding 100, damped beam by a factor of approximately 10.*

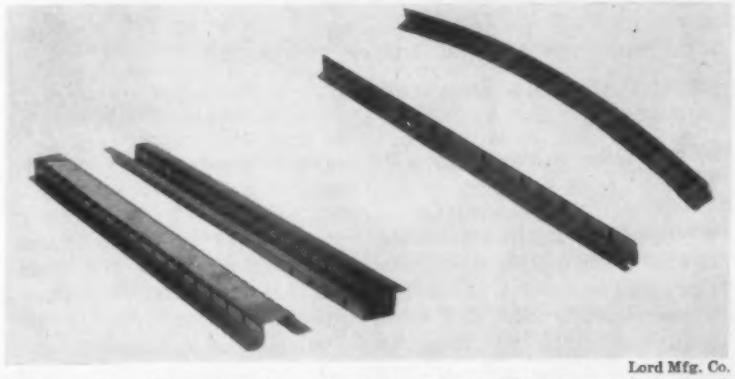
Barry Controls



**1b**—*At the first harmonic frequency (105 cps), conventional beam amplification factor is over 100, damped beam factor approximately 3. Ratio is >33.*



**1c**—*At the second harmonic (300 cps), vibration of the conventional beam is 50 times that of damped beam.*

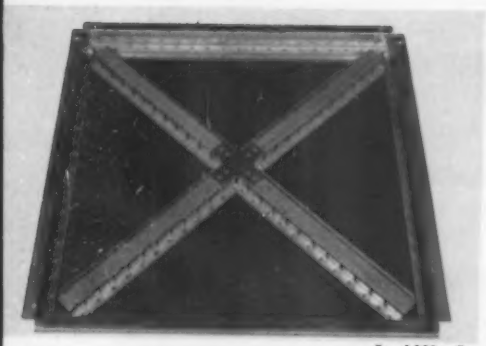


Lord Mfg. Co.

**2**—*Hat and angle sections formed from Dyna-damp. These are made by bonding a layer of BTR elastomer between slotted beam sections.*

Barry Controls

**3**—*Cellular construction of three Rigidamp beams. Steel insert is surrounded by viscoelastic damping medium.*



Lord Mfg. Co.

*4—Dyna-damp sections are applied to structural panels to reduce resonant response to "white" noise and vibration.*

sponse of the equipment. Barry proposes a strip damper of cell insert construction. Lord suggests that Dyna-damp be attached to panels in various patterns in order to reduce response to vibration (Fig 4).

It has been reported by Lord that in simulated operational fatigue tests the damped panels exhibited a life 20 times that of a solid aluminum sheet of equal thickness. Barry Controls also feels that built-in damping will improve fatigue life appreciably.

Some possible future applications include missile skins, aircraft parts, electronic chassis and circuit boards, etc.

**Availability**

Dyna-damp is available from Lord in either panel or structural section form.

Because special techniques must be used and the application knowledge required for design is critical, Barry does not plan to market damped structural members as materials. Instead it plans to provide design and fabrication services for structures to solve specific dynamic problems.

**For more information on Rigidamp, circle No. 602; on Dyna-damp, No. 605**

***FIRST EXCLUSIVE REPORT:***

# Organic Semiconductors Are On the Way

*with more versatility, easier processing, greater stability, lower cost*

**by Dr. Walter Brenner,** *Senior Research Scientist, New York University*

■ The recent Russian announcement of the development of a plastics semiconductor — irradiated polyacrylonitrile (M/DE, Feb '60, p 6)—has helped focus industrial attention on the rapidly growing technology of organic semiconducting materials. Such materials, now in the early development stages, may offer considerable improvements in versatility, cost, processability, and, in some cases, thermal and chemical stability, over the more common inorganic semiconductors (germanium, silicon, and the intermetallics).

A timely research conference on Semiconduction in Molecular Solids held in February at Princeton University served to summarize the results of work in this field. Essentially, there are three main types of organic semiconductors, aptly identified by Garrett of Bell Telephone Laboratories as 1) "mistreated" polymers, 2) charge transfer complexes, and 3) molecular crystals and other types of polymers.

**'Mistreated' polymers**

The most interesting group of organic semiconductors are polymers that have been rendered semiconductive by subjecting them to high energy radiation and/or rather severe thermal treatments. The Russian announcement referred to irradiated and pyrolyzed polyacrylonitrile and polyacrylonitrile-siloxane copolymers.

*Irradiated polyacrylonitrile* — The Russians reported that irradiation of polyacrylonitrile by gamma rays (dosage: 1.1 x $10^{22}$ ev) followed by thermal treatment resulted in a semiconducting material. Also, impregnating the polymer with metallic salts, such as cupric chloride and zinc chloride, prior to thermal treatment improved semiconducting characteristics. Specific conductivity of specimens impregnated and treated in this manner was reported to be $10^{-2}$ $ohm^{-1}$ -$cm^{-1}$ (resistivity of 100 ohm-cm) at 575 F. No decomposition occurred at 575 F, and the Russians claim that this semiconductor can operate at much higher temperatures than germanium.

*Polymer carbons*—In 1955 in this country, Baker and Winslow, of Bell Telephone Laboratories, reported electrical properties of certain pyrolyzed organic polymers, which they called "polymer carbons." Typical polymers used were crosslinked polystyrenes, polyvinylidene chloride, and silicones. The resulting polymer carbons were highly crosslinked, polymeric forms of carbon with complex chemical identity and considerable thermal stability. After pyrolysis such polymers exhibited thermal stability up to the temperature at which they had been treated. In most cases, substantial decreases in resistivity were reported (down to 100 ohm-cm and lower) after heat treatments above 1100-1300 F.

*Doped polymer carbons*—At the February conference, Pohl, of Princeton University, reported results of pyrolysis of certain metallic salt-impregnated ion exchange resins. Nickel and aluminum contents up to 12 at. % were used and temperatures were in

the 1300-2200 F range. Yields were on the order of 13%, based on the dry resin.

Conductivity increased with pyrolysis temperature. In nickel-doped polymer carbons, conductivity increased also with nickel content. In aluminum-doped polymers, conductivity decreased with aluminum content. The accompanying table compares properties of a typical polymer carbon with those of graphite, germanium and silicon. The concentration of conduction electrons in the polymer carbon appears to be large.

**Charge transfer complexes**

Charge transfer complexes are generally highly colored organic complexes which form between electron-donating and electron-accepting compounds. The strength of the bonding in these complexes is believed to depend on the extent of overlap of the donor and acceptor molecules. In some cases, specimens of such complexes can be prepared as single crystals, simplifying measuring techniques.

The surprisingly high conductivities of such complexes were first demonstrated by Inokuchi and Akamatu on polycyclic aromatic hydrocarbons and halogens, particularly iodine. A simple type of complex was formed, for example, by reacting the dye perylene, in benzene solution, with iodine. Other compounds complexed with iodine included violanthrene, dinaphthalene oxide, and indanthrene. The violanthrene-iodine complex was quite stable and showed a resistivity of 45 ohm-cm at room temperature. Other complexes exhibited resistivities ranging from 5 to 900 ohm-cm.

Among the more interesting complexes reported by Labes, of the Franklin Institute, was a p-phenylene diamine-chloranil complex with an extremely high Seebeck coefficient—up to 1.4 mv per °C (about seven times higher than that of bismuth telluride, one of the more promising intermetallic semiconductors).

**Other organic materials**

Molecular crystals were one of the early organic materials found to have semiconducting characteristics; more specifically, interesting photovoltaic effects. Semiconductive molecular crystals include such well-known organics as anthracene and naphthalene, as well as isobenzonthrone and other polynuclear hydrocarbons.

Another group of polymers, the phthalocyanines, have exhibited interesting resistivities and Hall effects, as well as exceptional thermal stability. Companies such as Monsanto and General Electric have devoted considerable research to such polymers and have found some phthalocyanines to have thermal stability above 840 F—stability unmatched by any other organic molecule.

## *The Background and the Future*

**The theory**

Organic semiconductors are frequently defined as organic materials whose electrical conductivity increases (or whose resistivity decreases) with increasing temperature. The following equation is used to describe the effect of temperature on the specific conductivity. or organic semiconductors:

$$\sigma = \sigma_o \, e^{-\Delta \epsilon / 2 k +}$$

where $\Delta\epsilon$ can be considered the apparent energy gap and $\sigma_o$ the conductivity extrapolated to infinite temperature (which presumably depends on the total carrier concentration and on the carrier mobility). Organic materials can be compared conveniently by these parameters.

**The past**

Research on organic semiconductors is not really new but has gained considerable momentum in the past few years. Classical organic chemical theory suggests that most organic substances comprised of primarily covalent-type carbon-carbon bonding systems should be insulators of electricity. This is indeed so. An excellent example is the high $10^{12}$ to $10^{15}$ ohm-cm resistivities of commercial plastics.

Probably the earliest studies of organic substances as intrinsic semiconductors were started in 1948 when Eley and Vortanyian discovered the unusual temperature dependence of the resistivities of the phthalocyanines and their metal derivatives. Since then many different organics have been found to exhibit such electrical resistance characteristics.

**The future**

Where these new materials will be used is still conjectural. One of the most intriguing possibilities is the field of thermoelectric devices. The lower thermal conductivity and higher Seebeck effects of the materials could provide "figures of merit" substantially better than those of presently used materials such as bismuth telluride.

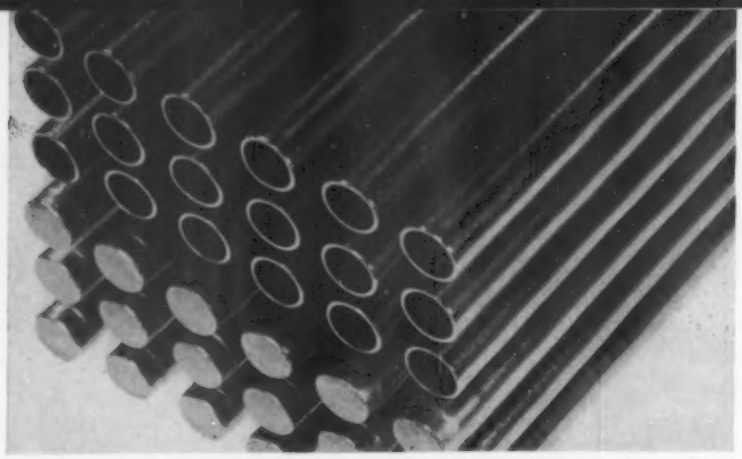
Certain of the materials (e.g., phthalocyanine polymers) provide thermal stability superior to that of metallic semiconductors now in use and under development. Also, the photovoltaic effects exhibited by certain organics (e.g., molecular crystals) may well be the basis for their use in many new detection or power generation devices.

Finally, suitably developed organic semiconductors may find wide use in rectifiers and transistors.

**SOME ELECTRONIC PROPERTIES OF SEMICONDUCTORS**

| Material ↓ | Band Separation (at 81 F), ev | $n_i$[a] | Density, gm/cu cm | N, atoms/cu cm[b] | $N_i/N$ |
|---|---|---|---|---|---|
| Graphite | 0.00 | $2.6 \times 10^{19}$ | 2.26 | $1.13 \times 10^{23}$ | $2.3 \times 10^{-4}$ |
| **Typical Polymer Carbon** | **0.06** | $\mathbf{8.3 \times 10^{18}}$ | **1.7** | $\mathbf{0.85 \times 10^{23}}$ | $\mathbf{1.0 \times 10^{-4}}$ |
| Germanium | 0.72 | $2.3 \times 10^{13}$ | 5.36 | $0.45 \times 10^{23}$ | $5.3 \times 10^{-10}$ |
| Silicon | 1.10 | $1.6 \times 10^{10}$ | 2.42 | $0.52 \times 10^{23}$ | $3.0 \times 10^{-13}$ |

[a]Number of carrier electrons per cu cm. [b]Number of total countable atoms per cu cm.



***Prototype tube bundle** joined by nickel diffusion bonding stood up satisfactorily in corrosion and strength tests.*

# Diffusion Bonding:

## A New Way to Join Critical Parts

*It can produce a joint with controlled microstructure closely resembling that of the base metal.*

**by W. P. McQuillan,** *Materials Engineering Dept., Westinghouse Electric Corp.*

■ Producing a joint with a controlled microstructure similar to that of the base metal is important in certain critical applications. Only in this way can optimum strength and corrosion resistance be achieved. Special brazing alloys can sometimes be developed, but in many assemblies—such as the atomic reactor tube bundle to be discussed here—alignment and tolerance considerations make it difficult to preplace a brazing alloy. Welding is often impractical because of the close spacing of components. The answer may lie in developing suitable ways of diffusion bonding.

## The process and the joints

**How it works**

One member of the joint is coated with an element that will form a eutectic with the base metal involved. Then the components are placed in contact with the coated member and the assembly is heated in vacuum to a temperature higher than the eutectic temperature of the alloy system. A liquid eutectic composition is formed which acts both as the brazing alloy and as a diffusion bridge. The amount of liquid formed is controlled by the thickness of the metal coating.

The idea of using, as a brazing alloy, a eutectic composition formed at an interface is not entirely new. Such a technique has been used in the copper-silver system in the past. Even some ancient jewelry was found to have been joined by the formation of a minimum-melting-point gold-copper composition.

The new process differs from earlier ones in several ways. For one thing, attention was given to using low melting eutectics formed with the iron, nickel or chromium already present in the alloy. Addition of any of these elements would lower corrosion resistance less than other elements that might have been used. Also, unlike earlier processes, the added elements are not purposely diffused away. The new technique was developed at the Bettis Atomic Power Laboratory.

**Diffusion bonding vs brazing**

Because the microstructure of the diffusion bonded joint can be carefully controlled, the same physical and mechanical properties can be obtained from every group of specimens of identical materials and dimensions. In brazed joints these properties vary with differences in joining temperature, or time, or thickness of the joint, or because of a difference in the amount of diffusion that results from the brazing operation.

Another instance where diffusion bonding may be more advantageous than brazing is where alignment and tolerance problems make it difficult to preplace the brazing alloy. Even if the alloy can be preplaced, the 0.002 to 0.005-in. thickness it adds may eventually cause dimensional difficulties. These difficulties are minimized with diffusion bonding which requires only a 0.0001-in. thickness of the diffuser element on one component. This small amount of electroplated diffuser element required also results in a cost saving.

For the purposes of the experiment to be described later, specimens were brazed with three brazing alloys and the joints compared with those of diffusion bonding. Only one brazed joint was successful, and it was accomplished with a special brazing alloy designed for the application. This alloy, with careful control of the brazing process, produced a joint microstructure that was similar to the base metal. Strength failure tests showed the brazed joint to be slightly superior to the diffusion bonded joint.

**Future uses**

At present, there is consider-

able interest in diffusion bonding. Some of the systems upon which work is being done are titanium to titanium, steel to steel, and copper to brass.

There are many more systems, especially those of high temperature alloys or of the extremely-high-melting metals, to which this method of joining may be applicable. In such applications, difficulties are often encountered due to weld cracking or the possibility of varying properties in brazed joints.

Diffusion bonding may also be used where simultaneous heat treatment and joining is desired.

## An experimental use: tube bundle for a reactor

The conclusions above are the result of an experimental use of diffusion bonding to assemble a trial tube bundle for a reactor. In the reactor design as developed at Westinghouse's Atomic Power Dept., Zircaloy-2 tubes had to be joined to tube spacers (ferrules) of the same material. Essential requirements of the joints were: adequate corrosion resistance to 650 F pressurized water, and sufficient strength to withstand mechanical loading in a reactor.

**Effect of process variables**

As will be true in any application or diffusion bonding, it was necessary to determine the following:

1. Material for the diffuser element.
2. Optimum thickness of the element.
3. Approximate joining temperature.
4. Approximate diffusion time.

*Materials*—For this experiment, the diffuser elements tried were nickel, chromium, iron and copper. The first three are present in Zircaloy-2; copper was tried because it had a satisfactory diffusion rate.

Nickel was the only successful diffuser element. When iron or copper was used, a fillet of the element remained and the bond was incomplete. Chromium formed an intermittent bond. With nickel, the microstructure of the joint was identical to that of the parent metal (see right). Hardness tests at various points in and around the joint gave consistent results for nickel, varied values for the other materials.

*Thickness*—Optimum thickness of the diffuser element was 0.0001 in. Tests made with 0.00017, 0.0005 and 0.0007-in. thicknesses of nickel diffuser element showed that coatings this thick were unsatisfactory from a corrosion resistance standpoint.

Because the chromium layer used to diffusion-bond the specimens was between 0.0005 and 0.0001 in. thick, results were inconclusive; further study must be made of the merits of chromium diffusion bonding.

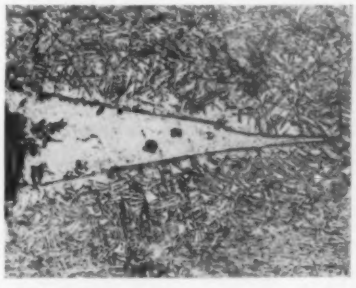
*Temperature*—The eutectic and joining temperatures, respectively, of the alloys used were:

| | Eutectic | Joining |
|---|---|---|
| Copper | 1625 F | 1832 F |
| Chromium | 2336 F | 2372 F |
| Iron | 1713 F | 1832 F |
| Nickel | 1762 F | 2012 F |

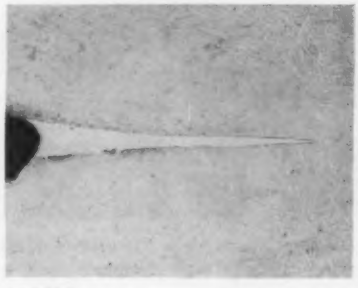
*Time* — The specimens — four tubes 1-in. long with 0.37-in. dia to be joined to a center tube spacer which had the diffuser element electroplated on it—were placed in a furnace under a 25-gm Zircaloy-2 weight. The system was pumped down to 0.05 $\mu$, heated to the joining temperature, and held 15 min at this temperature. Vacuum was maintained until the specimens were cool.

**Properties of the bonds**

The bonded assemblies were first corrosion tested in 650 F water at 2200 psi. Those specimens diffusion bonded with iron, copper, or thicknesses of nickel greater than 0.0001 in., exhibited heavy oxidation products after two weeks exposure. Both the 0.0001-in. nickel diffusion-bonded specimen and the specimen brazed with a special alloy (Zircaloy-2 + 4% beryllium) were satisfactory. They were coated only with the black oxide normally present on

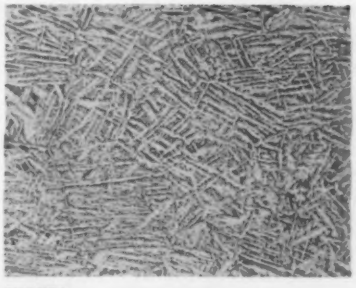


IRON



COPPER

CHROMIUM

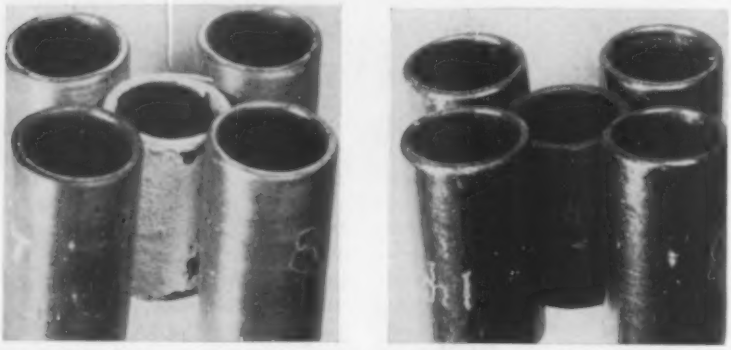


NICKEL

***Photomicrographs of four joints*** *made by diffusion bonding show that only nickel provides bonded microstructure similar to the parent metal.*

corrosion-tested Zircaloy-2 alloy.

Double shear and Izod impact tests were made on the two types of satisfactory specimens—the 0.0001-in. nickel diffusion bonded specimen and the brazed specimen. Results are reported in the accompanying tables.



***Corrosion tests** performed in 650 F water at 2200 psi show extreme oxidation on specimens diffusion bonded with copper (left) and normal oxidation on 0.0001-in. specimens diffusion bonded with 0.0001-in. nickel.*

**JOINT STRENGTH—DOUBLE SHEAR**

| Test Temp, F | Joint Type[a] | Joint Length, in.[b] | Fillet Width, in. | Failure Load, lb[c] | Location of Failure[c] |
|---|---|---|---|---|---|
| 68 | Diffusion | 0.259, 0.275 | 0.05 | 685, 1271 | Fillet, base metal |
| | Brazed | 0.249, 0.252 | 0.07 | 1275, 1500 | Base metal, base metal |
| | Diffusion | 0.525 | 0.05 | 2152 | Center tube |
| | Brazed | 0.52 | 0.09 | 2030 | Center tube |
| 650 | Diffusion | 0.254, 0.248 | 0.05 | 300, 656 | Fillet, fillet |
| | | 0.264, 0.237 | 0.05 | 415, 715 | Fillet, base metal |
| | | 0.240, 0.273 | 0.06 | 425, 810 | Base metal, fillet |
| | Brazed | 0.240, 0.245 | 0.09 | 876, — | Base metal, base metal |
| | | 0.246, 0.246 | 0.09 | 569, 937 | Base metal, base metal |
| | | 0.266, 0.251 | 0.09 | 900, — | Base metal, base metal |

[a] "Diffusion" refers to bonds formed with 0.0001-in. nickel diffuser element. "Brazed" refers to bonds formed with special brazing alloy: Zircaloy-2 + 4% beryllium.
[b] The specimen consisted of a center tube with a tube bonded to each side; the two lengths given refer to the two separate bonds.
[c] The two values refer to the two bond lengths, respectively.

**JOINT STRENGTH—IMPACT**

| Test Temp, F | Joint Type[a] | Joint Length, in. | Fillet Width, in. | Impact Strength, ft-lb[b] | Location of Failure |
|---|---|---|---|---|---|
| 68 | Diffusion | 0.235 | 0.05 | 1.25 | Base metal |
| | | 0.235 | 0.05 | 0.50 | Fillet |
| | Brazed | 0.275 | 0.125 | 1.5 | Base metal |
| | | 0.275 | 0.09 | 0.5 | Fillet |
| 650 | Diffusion | 0.20 | — | 2.75 | Base metal |
| | | 0.24 | 0.04 | 1.0 | Base metal |
| | | 0.27 | 0.03 | 2.0 | Base metal |
| | Brazed | 0.295 | 0.063 | 2.75 | Base metal |
| | | 0.275 | — | 3.25 | Base metal |
| | | 0.270 | 0.09 | 2.50 | Base metal |

[a] "Diffusion" refers to bonds formed with 0.0001-in. nickel diffuser element. "Brazed" refers to bonds formed with a special brazing alloy: Zircaloy-2 + 4% beryllium.
[b] For comparison, the same impact test performed on Zircaloy-2 tubing (⅜-in. o.d., 0.030-in. wall thickness) gave an impact strength of 5.5 ft-lb at 68 F, 9.25 ft-lb at 650 F.

When a 0.5-in. overlap was used in the test pieces, joints of both types failed in the base metal rather than the joint. With only a 0.25-in. overlap, 70% of the diffusion bonded parts failed in the fillet during shear testing, whereas most of the brazed parts failed in the base metal.

The brazed joints also appear to have somewhat greater impact strength. Nevertheless, only one diffusion bonded joint failed in the fillet even though the width of the diffusion bonded joint was only one-half the width of the brazed joint fillet.

### Prototype is satisfactory

Having determined the optimum conditions for diffusion bonding the reactor tube bundle, and having proved by tests that this joining method was adequate for the application, Westinghouse engineers constructed a prototype tube bundle (photo at left).

This unit had 36 8-in. long tubes (⅜-in. o.d., 0.030-in. wall) separated by tube spacers at each end. The spacers at one end of the unit (as well as the necessary end plugs) were diffusion bonded using 0.0001-in. nickel. Brazing was used for the spacers at the other end.

Joints at both ends proved satisfactory in tests, although the diffusion bonded joints had smaller fillets. Strength was adequate in both cases, and neither end showed corrosion attack after two weeks. The only oxidation products observed occurred in the end plug joints where some of the nickel diffuser element accumulated after being scraped off when the plugs were inserted.

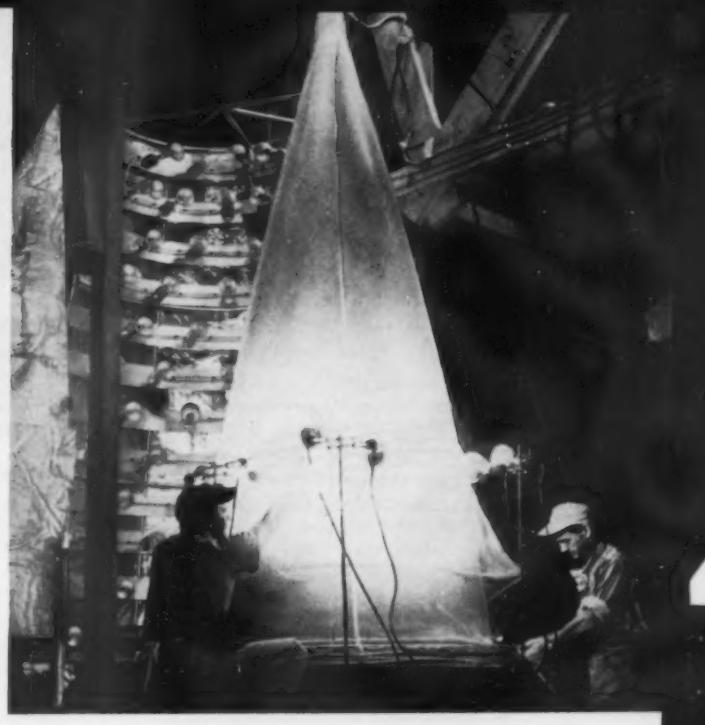
Before diffusion bonding is specified for this particular use, however, further work must be done in evaluating the effect of excessive nickel concentration in Zircaloy-2. Further tests should also be made with a thinner layer of chromium as the diffuser element. The chromium diffusion bond was not corrosion tested because the melting point of its eutectic composition was considered too high for practical application.

**For more information, circle No. 603**

**NEW EPOXIES—1**

*For filament winding . . .*

*or vacuum bag molding . . .*



# Epoxy Resin Is Strong at 500 F Plus

*and has good handling characteristics*

**by S. A. Miller,** *Chief R & D Engineer, and* **V. A. Chase,** *Senior R & D Engineer, Brunswick-Balke-Collender Co.*

***High temperature radomes*** *are a promising application for the new resin system.*

■ A new high temperature epoxy formulation appears to successfully overcome two major drawbacks of present epoxy laminating resins. These are:

1. Unsatisfactory performance of laminates in the 500 F temperature range, as specified for Type II parts under MIL-R-9300-A.

2. Difficulty in adapting high temperature epoxy resins to low pressure vacuum bag or filament winding production techniques.

The accompanying table shows that laminates made from the new resin formulation, designated VC-8359, exceed requirements of the specification in all respects. Handling characteristics are excellent. Wettability and viscosity are such that several plies can be laid down and impregnated at once, as opposed to the standard procedure of impregnating one ply at a time. The material also has a long pot life.

**The resin**

The resin formulation, developed by Brunswick, is based on one of Union Carbide Chemical's diepoxides derived from peracetic acid. (See M/DE, Dec. 58, p 128.) The resin system is highly functional, and thus capable of a high degree of cross-linking. Data given here are for an anhydride-cured system.

**Mechanical properties**

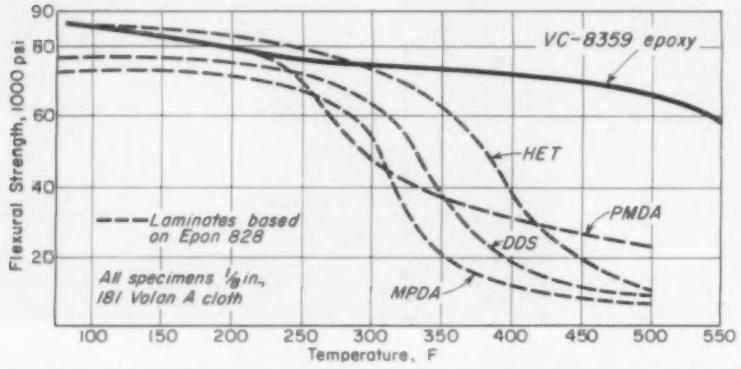
The superior heat resistance of laminates made with the new material is shown in the accompanying curves. Fig 1 compares the material with a conventional bisphenol-A epoxy cured with various high temperature anhydride curing agents. Note that

flexural strengths are about comparable up to the 250-300 F range, but those of conventional epoxies fall off rapidly from 300 to 500 F.

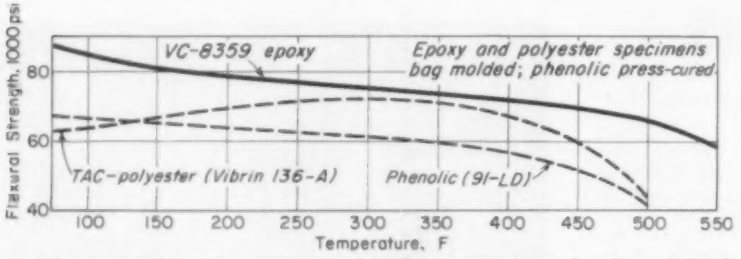
Fig 2 compares the material with a high temperature phenolic (91-LD) and a TAC-polyester (Vibrin 136) laminate. Percentage of overall reduction in flexural strengths from room temperature to 500 F is about the same, but flexural strength of the epoxy is higher in all cases.

Fig 3 compares compressive strength of the material with that of a high temperature epoxy laminate cured with three different curing agents.

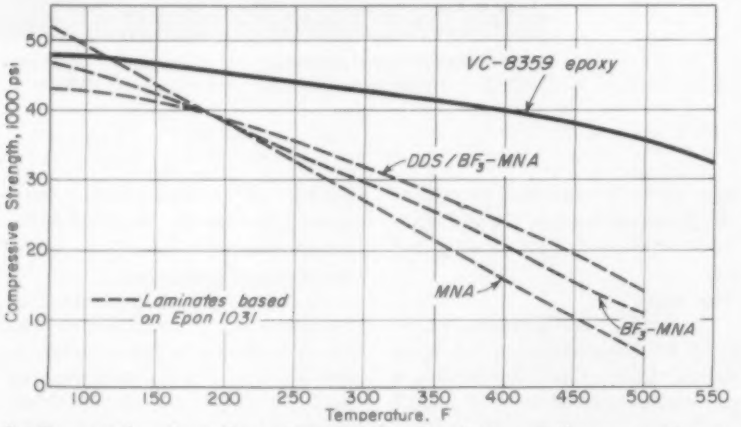
Although effects of temperatures as high as 600 F have not been thoroughly studied, preliminary evaluation work appears promising.




*1—Flexural strength vs temperature. Laminates made with the new VC-8359 resin are compared with four conventional epoxy laminates. Abbreviations indicate type of anhydride curing agent used.*




*2—New epoxy, VC-8359, compared with high temperature phenolic and TAC-polyester laminates. Data on the phenolic and polyester laminates were extracted from WADC Rpt. 59-469.*




*3—Compressive strength vs temperature. Laminates of the new resin are compared with a previously available high temperature epoxy resin, cured with different hardeners (abbreviated).*

**Electrical properties**

In aircraft radar antennas and housings, dielectric constant and loss are the two most critical electrical characteristics. The table shows these properties for the new modified epoxy in laminate form; a footnote gives values for unfilled castings.

Obviously, resin-glass ratio af-

**TYPICAL PROPERTIES OF VC-8359 LAMINATE**

| | MIL-R-9300-A Requirements | VC-8359[a] |
|---|---|---|
| **MECHANICAL PROPERTIES** | | |
| Flex Str, 1000 psi | | |
| Room Temp | 70 | 89 |
| Wet (2 hr, boiling water) | 65 | 74 |
| 160 F, ½ Hr | 65 | 76[b] |
| 500 F, ½ Hr | 22 | 66 |
| 550 F, ½ Hr | None | 58 |
| 500 F, 192 Hr | 18 | 48 |
| Flex Mod of Elast, $10^6$ psi | | |
| Room Temp | 3.2 | 3.53 |
| Wet | 2.2 | 3.24 |
| 160 F, ½ Hr | 3.2 | 3.22[b] |
| 500 F, ½ Hr | 2.0 | 3.18 |
| 550 F, ½ Hr | None | 3.16 |
| 500 F, 192 Hr | 1.8 | 2.48 |
| Ult Ten Str, 1000 psi | | |
| Room Temp | 47 | 52 |
| Wet | 45 | 55 |
| 500 F, ½ Hr | 20 | 41 |
| Ult Compr Str (edgewise), 1000 psi | | |
| Room Temp | 50 | 48 |
| Wet | 45 | 47 |
| 500 F, ½ Hr | 10 | 35 |
| Hardness (Barcol) | 60 | 80 |
| **PHYSICAL PROPERTIES** | | |
| Water Absorption (24 hr), % | 0.5 max | < 0.5 |
| Specific Gravity | Shall be noted | 1.97 |
| Dielectric Constant | | |
| Dry | 4.6 | 4.41[c] |
| Wet | 4.6 | 4.46[c] |
| Loss Tangent | | |
| Dry | 0.020 | 0.017[c] |
| Wet | 0.025 | 0.017[c] |

[a] Specimens: 12-ply, ⅛ in. thick, 181 cloth, Volan A finish, 30% resin. Test methods as specified in Fed Spec LP-406-b; all tests at room temperature except as noted.
[b] Tested at 250 F.
[c] Tested at 9375 mc. Other tests showed unfilled castings to have dielectric constant of 2.99; loss tangent of 0.023; specific gravity of 1.34.

fects electrical properties of laminates. Fig 4 shows how resin affects dielectric constant.

Initial work indicates that with slight modification the resin may be adapted to encapsulation or potting for high temperature use. However, precise data on exotherm of the material are not available as yet.

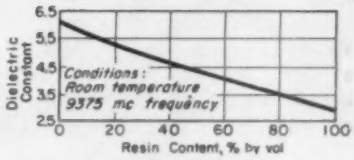
Postcuring the resin at temperatures below 500 F produces a translucent material with excellent electrical properties at temperatures up to the postcure peak temperature.

**Processing characteristics**

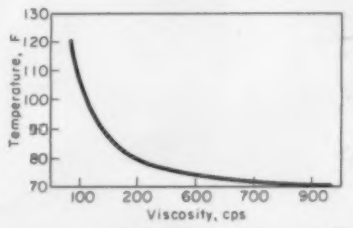
VC-8359 was designed specifically for use in filament winding or low pressure laminating. The material has excellent wettability and low viscosity, as shown in Fig 5; when catalyzed, it has good pot life, as shown in Fig 6. B-stage roving or laminates have long shelf life.

The resin contains no solvents and can be cured relatively quickly. A typical cure sequence for optimum high temperature properties is 3 hr at 300 F, 2 hr at 350 F, 2 hr at 450 F, and 1 hr at 500 F. Optimum strengths are obtained with molding pressures of about 11 psi. Extended postcures do not appear to substantially improve physical properties or thermal stability.

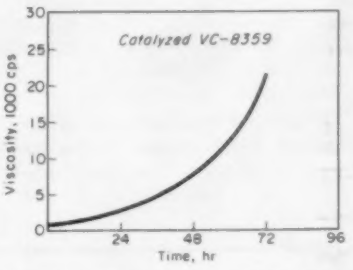
For more information, circle No. 604




***4**—Effect of resin content on dielectric constant of laminates.*




***5**—Viscosity vs temperature. Curve shows that mild heating can substantially lower viscosity of the material.*




***6**—Viscosity vs time. Gradual increase of viscosity with time for catalyzed material indicates long pot life.*

***Editor's Note***

*Heat Resistant Epoxies —Keep Them Straight*

Up to a couple of years ago all epoxy resins were the bisphenol-A type (reaction products of epichlorohydrin and bisphenol-A). The maximum heat resistance obtainable in these types was around 300-350 F with an acid anhydride cure.

Within the last few years several epoxy-novolac resins (reaction products of epichlorohydrin and a phenolic resin) have been marketed, the most recent being Dow Chemical's DEN 438, announced in our January issue (p 9). This resin is also aimed at the 500 F temperature range.

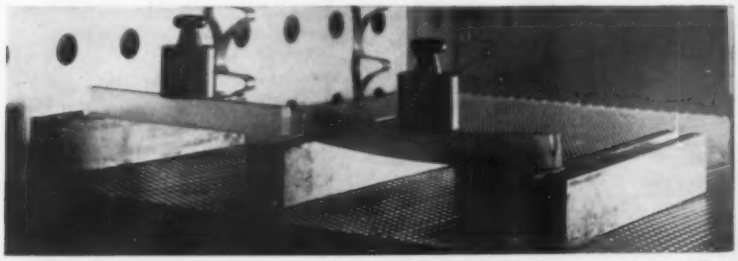
In Dec '58, we announced Union Carbide Chemical's development of peracetic acid-derived diepoxies (produced through the oxidation of olefins with peracetic acid). At that time, materials were available only in developmental quantities. This article presents the first engineering data on a commercial formulation (VC-8359) based on these materials.

The next article in this issue, (see below) describes still another new family of epoxy resins—Food Machinery and Chemical's Oxirons—which are epoxidized polyolefins. They also appear to have interesting heat resistance characteristics.

***NEW EPOXIES—2***

# Family of Epoxies Is Light, Strong, Heat Resistant

*Favorable curing properties promise cost savings*



***Good heat resistance** is shown by specimen of new resin at left which is sagging only 1 mil under 100-mg weight in 410 F oven. Conventional epoxy at right sags 40 mils.*

■ Improvements in heat resistance and strength-weight ratio, plus lower ultimate materials cost, appear to be among the most promising characteristics of a radically new family of epoxy resins recently introduced by Food Machinery and Chemical Corp.'s Epoxy Dept. FMC expects its materials to expand the market for epoxies in casting and encapsulation, reinforced laminates, adhesives and coatings systems.

Specific comparisons are diffi-

cult because of the variety of epoxies now being produced. But in comparison with conventional bisphenol-A epoxies, the new resins (called Oxiron) in cast form have excellent heat resistance. Heat distortion temperatures (264 psi) are as high as 430 F. The materials have good mechanical strength; with tensile strengths as high as 10,000 psi; flexural strength of 18,000 psi; flex modulus of 490,000 psi.

The potentially lower cost stems from the materials' lighter weight —about 10-15% less than conventional epoxies—and their reactivity with low cost anhydride curing systems (e.g., maleic anhydride and propylene glycol). According to the producer, materials costs using an optimum formulation in a reinforced plastics boat might be closer to those of polyesters than epoxies.

Electrical properties and chemical resistance are comparable to those of other epoxies.

**Reactivity the key**

As epoxidized polyolefins, the Oxiron resins have a higher degree of reactivity than conventional epoxies. Also, they react differently with curing agents, so they should not be substituted in other epoxy formulations. Oxiron resins have as many as five or more reactive epoxy sites, both external and internal, on the aliphatic hydrocarbon chain that forms the molecule's backbone. Also, hydroxyl groups provide further reactivity. Briefly, the different curing agents provide the following general characteristics:

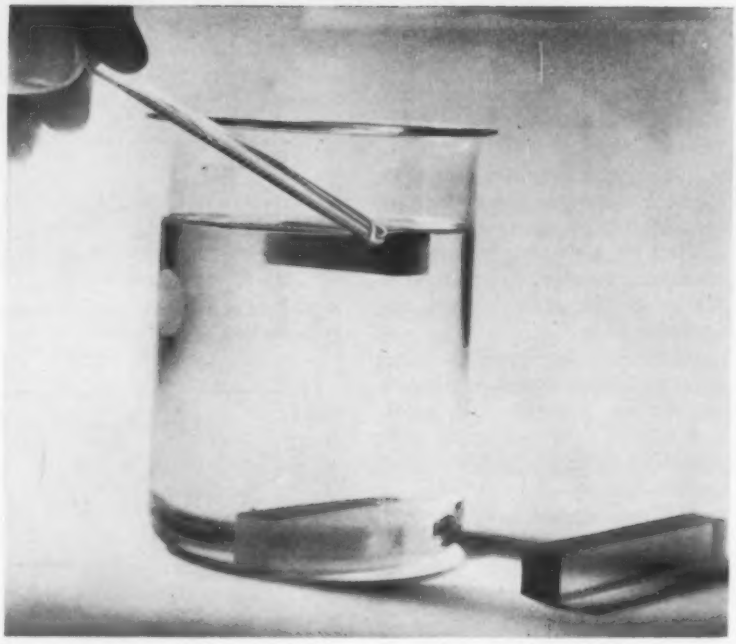
Anhydride—High heat distortion temperatures; good low temperature reactivity permits low temperature, fast cures.

Anhydride-glycol — Low cost, good low temperature reactivity, low viscosity.

Peroxide—Excellent heat resistance, good physical properties.

Polyamine—Long pot life at room temperature, rapid cure at elevated temperatures, good resistance to high temperature aging.

Three types are available for laminating and casting applications. Oxiron 2000 has a viscosity of 1800 poise; 2001 a viscosity of 160 poise; and 2002 is an extremely low viscosity material (15 poise) with greater double bond reactivity than the other two.



***Light weight** of the new epoxies is shown by this specimen immersed in beaker of chlorinated solvents. New resin floats; conventional epoxy (about 10-15% heavier) sinks.*

Introductory price is $1.75-$2.00; commercial price is expected to be comparable to that of conventional epoxies, i.e., about 68¢ per lb.

*(continued on p 189)*

MORE WHAT'S NEW IN MATERIALS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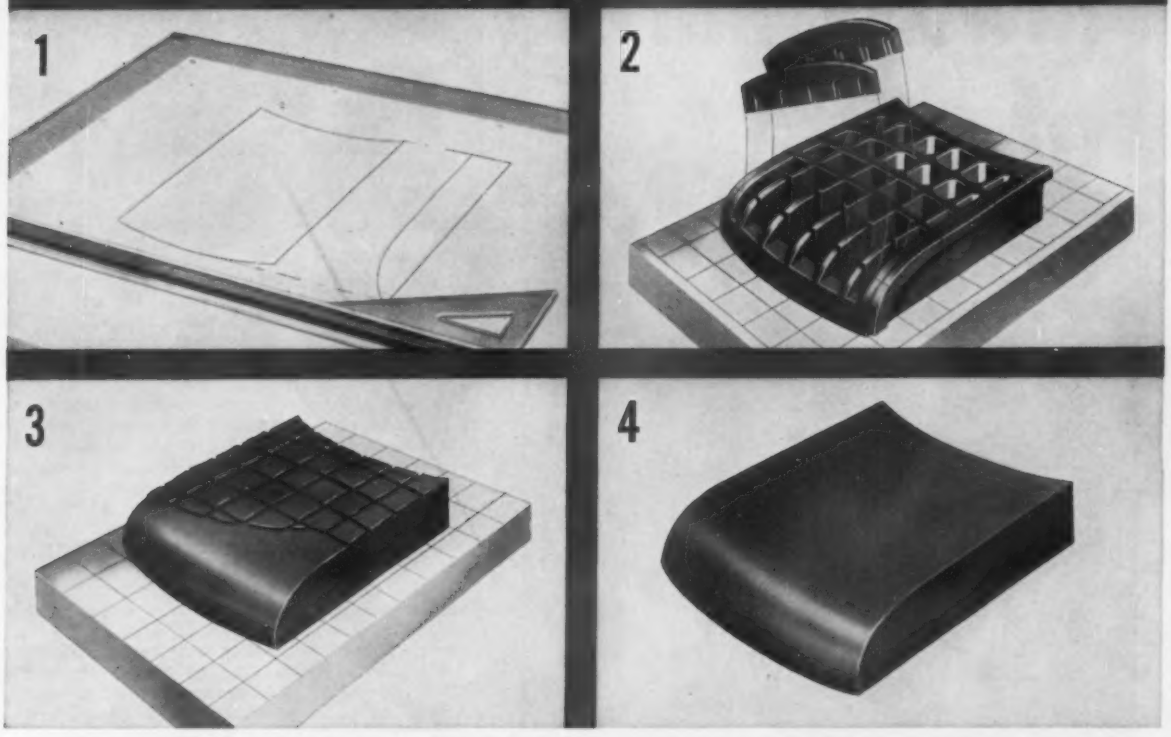
# NOW! A FAST, ECONOMICAL METHOD FOR MAKING MASTER MODELS

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(3) The open areas of the "egg crate" are filled with Kish No. 44 Resin Compound (formulated with RCI EPOTUFS) and after the compound cures the rough model is shaped and finish-surfaced using standard woodworking techniques.

(4) The finished model is grain-free, dimensionally stable, and unaffected by moisture and weather. It will not chip or deteriorate with age and can be altered simply by bonding additional Epotuf-based material on the model.

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**Complete information on the Kish System is available from Kish Industries, Inc., 1301 Turner Street, Lansing 6, Michigan.*

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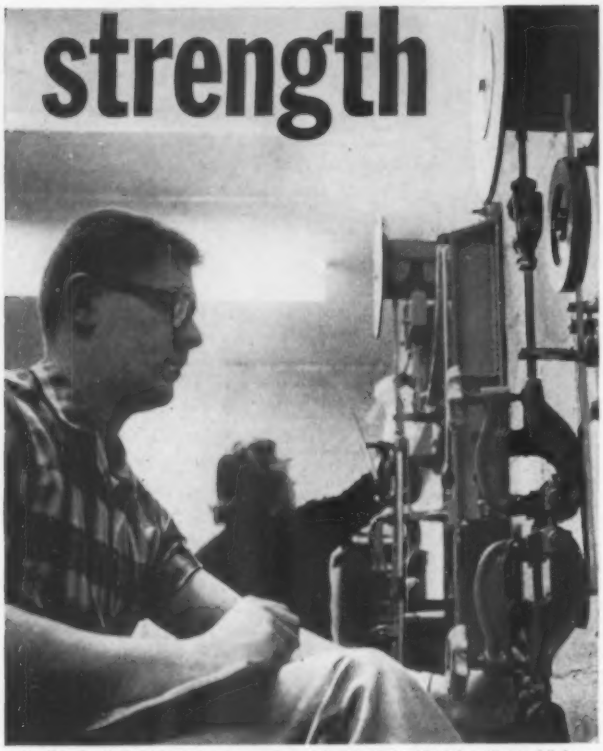

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### European comment on a materials society

To the Editor:

We have read with a great deal of interest the discussion between Messrs. F. L. LaQue (M/DE, Oct '59, p 249) and H. R. Clauser (M/DE, July '59, p 212, and Oct '59, p 250) about a technical society that is concerned with all types of engineering materials.

You might be interested to know that in the Netherlands we have a materials society composed of seven groups, with each group concerned with a specific material, class of materials, or property.

Materials or properties that concern each group are 1) building materials, 2) metals, 3) rheology, 4) wear, 5) lubricants and lubrication, 6) paints, rubber, asphalt and plastics, and 7) fibers and cellulose.

Each group has a board of directors and a president selected from the board of directors of the parent organization. Each unit organizes lectures on an academic level dealing with its special subject.

Under the supervision of the group boards, regional discussion groups are formed to discuss practical technical problems. Study groups are selected to study fundamental material problems.

Furthermore, courses have been organized by the parent association to train technicians on a university, technical high school and lower technical high school level. For this purpose a special foundation was formed which is financially supported by the Dutch government.

H. HOUWINK
Director
Bond Voor Materialenkennis
(Assn. for the Advancement
of the Knowledge of Materials)
The Hague, Netherlands

### Origin of electron beam welding

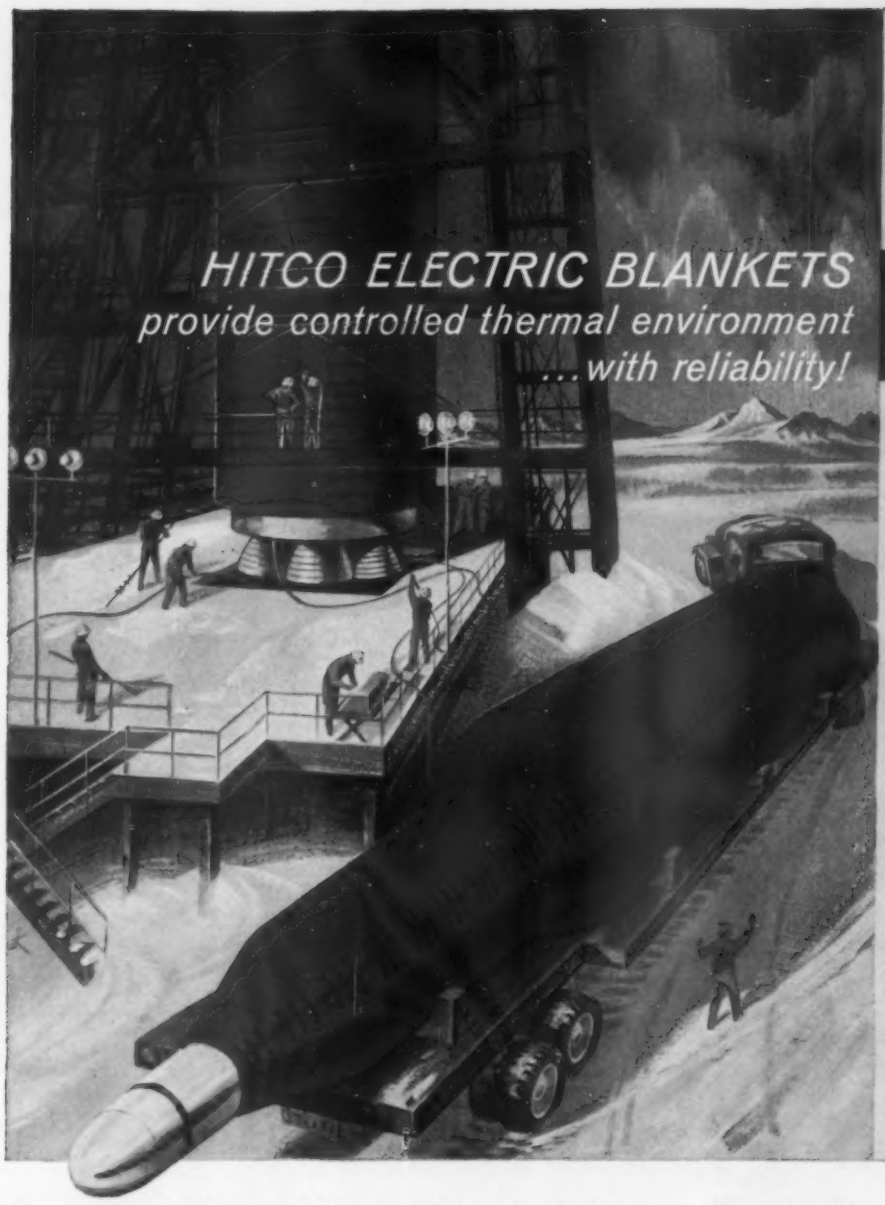
To the Editor:

I want to compliment you on the article "The New Welding Processes," (Manual No. 166), Jan '60, p 105. I think you have published a good balanced presentation of these new processes.

There is only one small correction I might suggest: the origin of electron beam welding is not entirely European as the article indicates.

Simultaneous to the development of this process by the French Atomic Energy Commission, two men at the Hanford Laboratory of the Atomic Energy Commission (operated by General Electric Co.) independently developed essentially the same equipment. The men were Walt Wyman and Bill Steinkamp. Their work was first reported in the Feb '58 issue of the *Welding Journal*.

Since their work was completed and publicly announced in Feb '58, it appears a bit improbable



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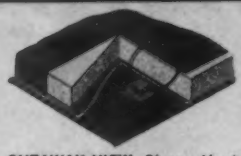
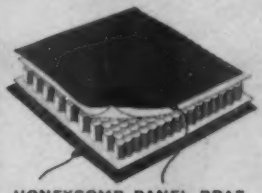


**CUTAWAY VIEW.** Shows Heating Element of HITCO Electric Blanket—sealed between cover and inner cover.



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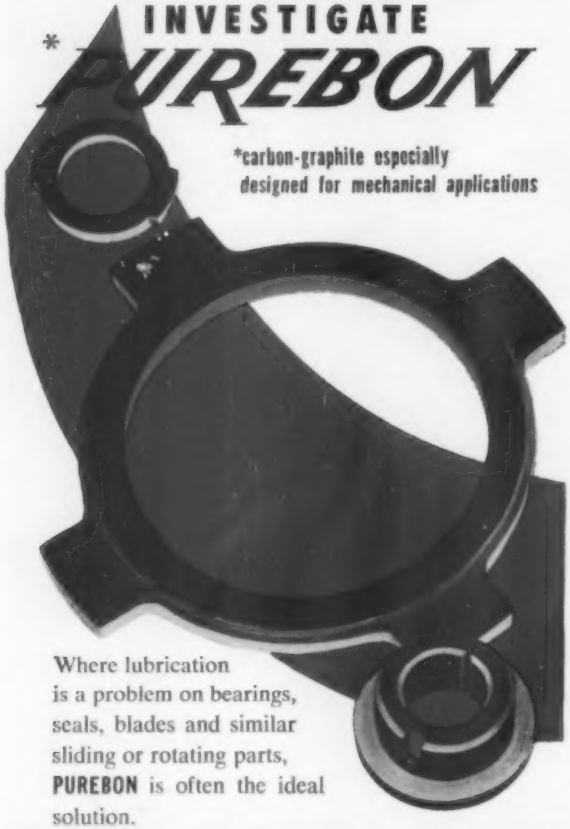

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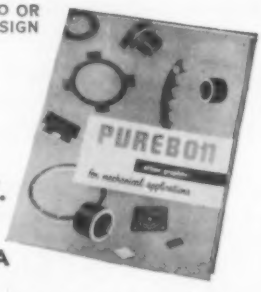


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that the first laboratory electron beam welder was set up in this country in 1958.

A correction to properly give credit to the work done by these two gentlemen might well be in order.

G. S. HOPPIN III
Manager
Metallurgical Processes Unit
Flight Propulsion Laboratory Dept.
General Electric Co.
Cincinnati 15, Ohio

### Porous alumina plate

To the Editor:

We need a porous aluminum oxide plate 3 in. wide by 12 in. long by ¾ in. thick with a permeability of approximately 14 cu ft of air per sq ft per min under a pressure differential of about 2 in. of water. The plate will be used in a fluidized bed dryer.

H. W. KRUGER
7700 S.W. Canyon Dr.
Portland 25, Ore.

### Welding type 300 stainless steel

To the Editor:

The Joinability of Materials table on p 432 of the *1959-60 Materials Selector* recommends arc welding for type 300 series stainless steel and silver brazing for all other types of stainless steel.

It is true that the 300 series stainless steels may be joined by arc welding, provided the welded assemblies are subjected to a suitable post weld heat treatment to combat sensitization, the "number one" drawback of these steels. The only exceptions are types 321 and/or 347 which contain titanium and columbium to combat this phenomenon.

The flow temperature of most silver solders is well within the dangerous sensitization temperature range of 850 to 1475 F; the crucial sensitization temperature range is 900 to 1300 F. The maximum time in this temperature range should not exceed 2 to 3 min.

It is suggested that the tabular comments on arc welding of stainless steels be revised to read "Recommended for 300 series with suitable post weld heat treatment."

The silver brazing comments could be revised to read "Recommended for all types, except the unstabilized alloys of the 300 series, if subsequently subjected to corrosive environments."

G. R. CURRAN
Engineer
Raytheon Mfg. Co.
Bedford, Mass.

**WIN CASH—Each month $10 will be paid for the best letter written to an author (through us), an editor, or addressed to this column. We reserve the right to withhold awards.**

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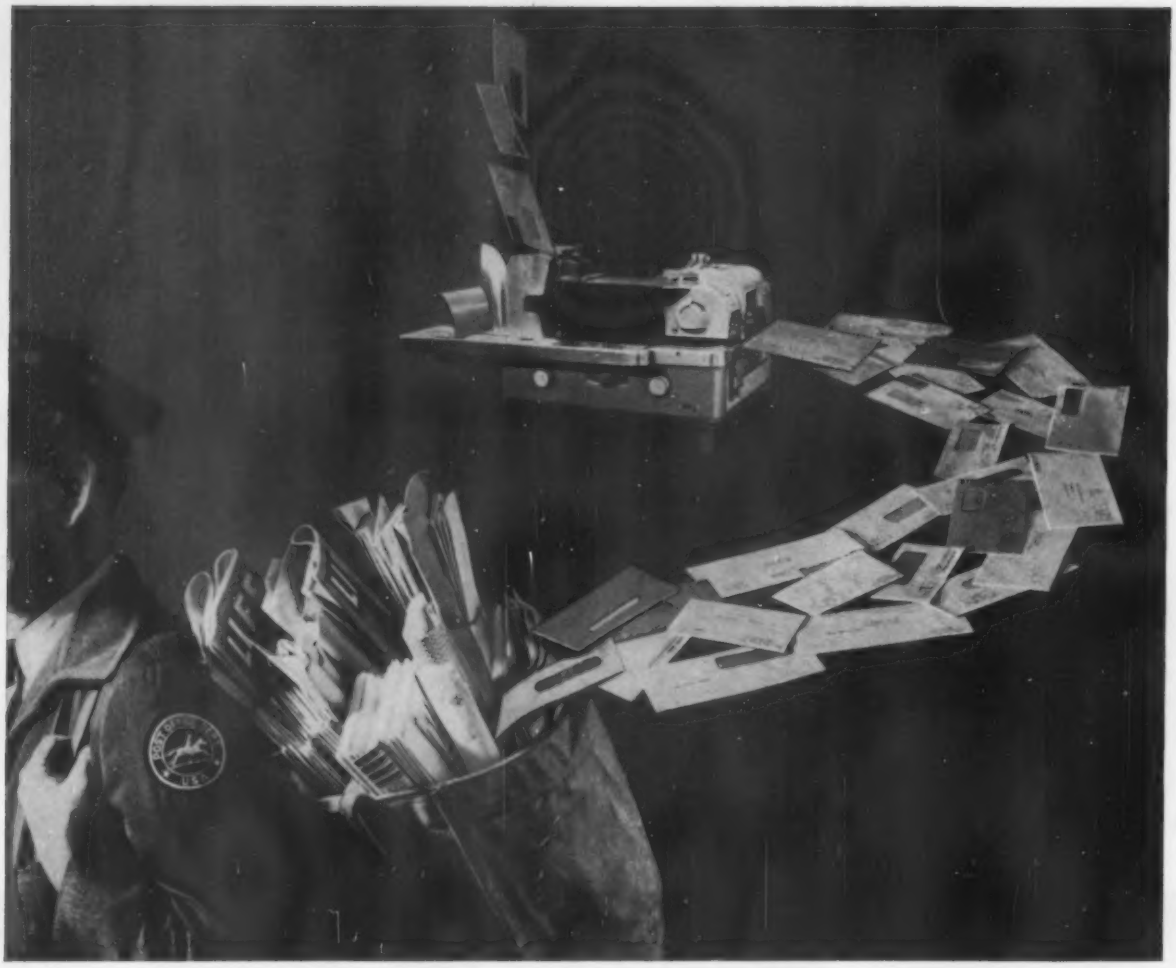

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# PRICES & SUPPLY

## ...AT A GLANCE

**Price cuts on a number of engineering materials** have been announced recently. Some of the most important:

**Two rigid ABS materials** have been reduced in price. Marbon Chemical's Cycolac natural pellets drop from 58¢ to 49¢ per lb; standard and custom colored pellets from 58¢ to 51¢ per lb; and natural powder from 53¢ to 45¢ per lb. U. S. Rubber's Kralastic drops an average of 16%.

**A high impact acrylic** molding powder, Implex, has been reduced by Rohm & Haas Co. New truckload price is 46½¢ per lb for natural color, 48½¢ for pigmented grades. The new prices represent reductions of approximately 17% and 19%, respectively.

**Organo-silicone copolymers** have been reduced from $2.56 per lb to $2.48 per lb by the Silicones Div., Union Carbide Corp. Not long ago price of the material was dropped from $2.80 to $2.56 per lb (see M/DE, Jan '60, p 21).

**Hypalon synthetic rubber** (chlorosulfonated polyethylene) has been reduced 10 to 23¢ per lb, depending on type, by Du Pont.

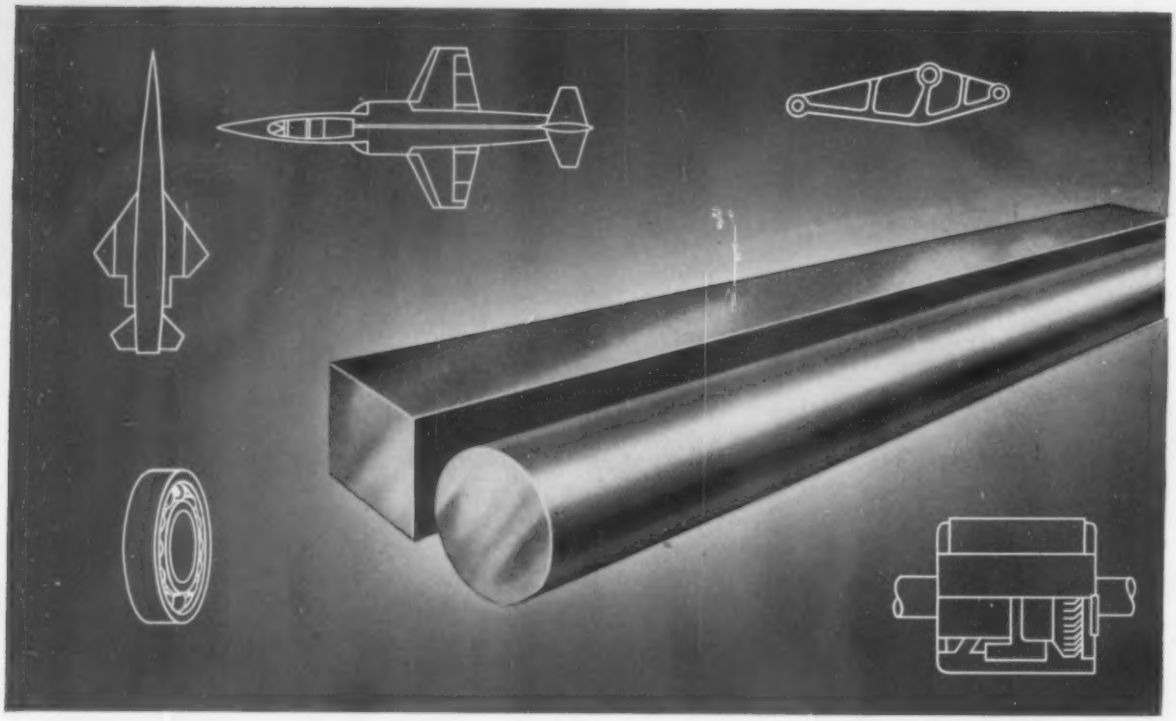
**Major grades of aluminum alloy pig** have been reduced by the three primary producers (Alcoa, Kaiser and Reynolds). The reductions average 3%, or ¾¢ per lb.

**Output of styrene monomer will be greatly increased** as a result of Dow Chemical's latest expansion. The increase (amount not revealed) will raise the company's annual capacity to more than 800 million pounds. Styrene monomer is used in the manufacture of SBR synthetic rubber, polyester and polystyrene resins, and other polymers and copolymers.

**Nickel supply is plentiful.** According to government sources, "Stocks of surplus nickel more than offset any curtailment of supply from Cuban production this year."

**More enamel-coated aluminum sheet** will be available late this year when production facilities at Alcoa's Davenport, Ia. plant are doubled. Alcoa's enamel-coated sheet, called Tone-Cote, is presently available in 19 standard colors, and in thicknesses ranging from 0.019 to 0.051 in.

**The largest amount of steel ever made in one month** was produced this past January. Total: 12,043,000 net tons. According to American Iron and Steel Inst., the previous monthly record was 11,989,319 net tons in Dec '59. Steelmaking facilities were used an average 95.4% of capacity in January.



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| Yield Strength .2% (psi) | 252,500 | 250,000 |
| Elongation % | 8 | 8 |
| Reduction of Area % | 25 | 24 |

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# Navy's Materials Problems Discussed by AIME

A review of the Navy's materials problems was one of the highlights of the recent annual meeting of the Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers.

**Symposium is new approach**

The symposium, initiated by the Institute of Metals Div., represents a new approach to the problem of communication between military and civilian metallurgists and scientists. Additional symposia along these lines are planned for the Army and Air Force.

One session of the "Navy Day" symposium was devoted to materials applications. Of special interest were the discussions of materials for deep diving submarines, missiles and other aerial vehicles, and materials for energy conversion. The second session was devoted to specific materials problems with which the Navy is currently actively engaged. Among these were: refractory metals, thermoelectric materials, semiconductors, crack initiation and propagation, and effects of radiation on materials.

**Metals industry chided**

In the traditional Howe Memorial Lecture, Dr. Robert F. Mehl, Carnegie Institute of Technology, took the metals industry to task for abrogating its research responsibilities and allowing chemists and chemical engineers to perform the major tasks in the development of newer metals.

**Unified education proposed**

Some interesting comments were also made on the subject of engineering education. Dr. John Dorn, University of California, suggested that a unified engineering-science education program be developed for metallurgists on the undergraduate level. The proper time for specialization, he felt, was at the graduate level.

The newly elected president of the Metallurgical Society, Dr. C. C. Long, had some important comments to make on the role of metallurgists as experts in "materials." Because the concepts developed by research metallurgists are being applied broadly to engineering materials in general, metallurgical engineers, Dr. Long feels, are becoming increasingly concerned with the study and useful application of all materials, rather than of metals only.

**Be sure to see . . .**


- Page 53 for complete details on registration, technical program and exhibitors at the 16th annual MPI Meeting and 1960 Powder Metallurgy Show, Apr 25-27, Chicago.
- Page 184 for a report on special engineering materials short courses, symposia, seminars, etc. being offered by leading universities and colleges.


# Four Groups to Meet in April, May

Four trade societies will hold meetings on engineering materials during the next five or six weeks:

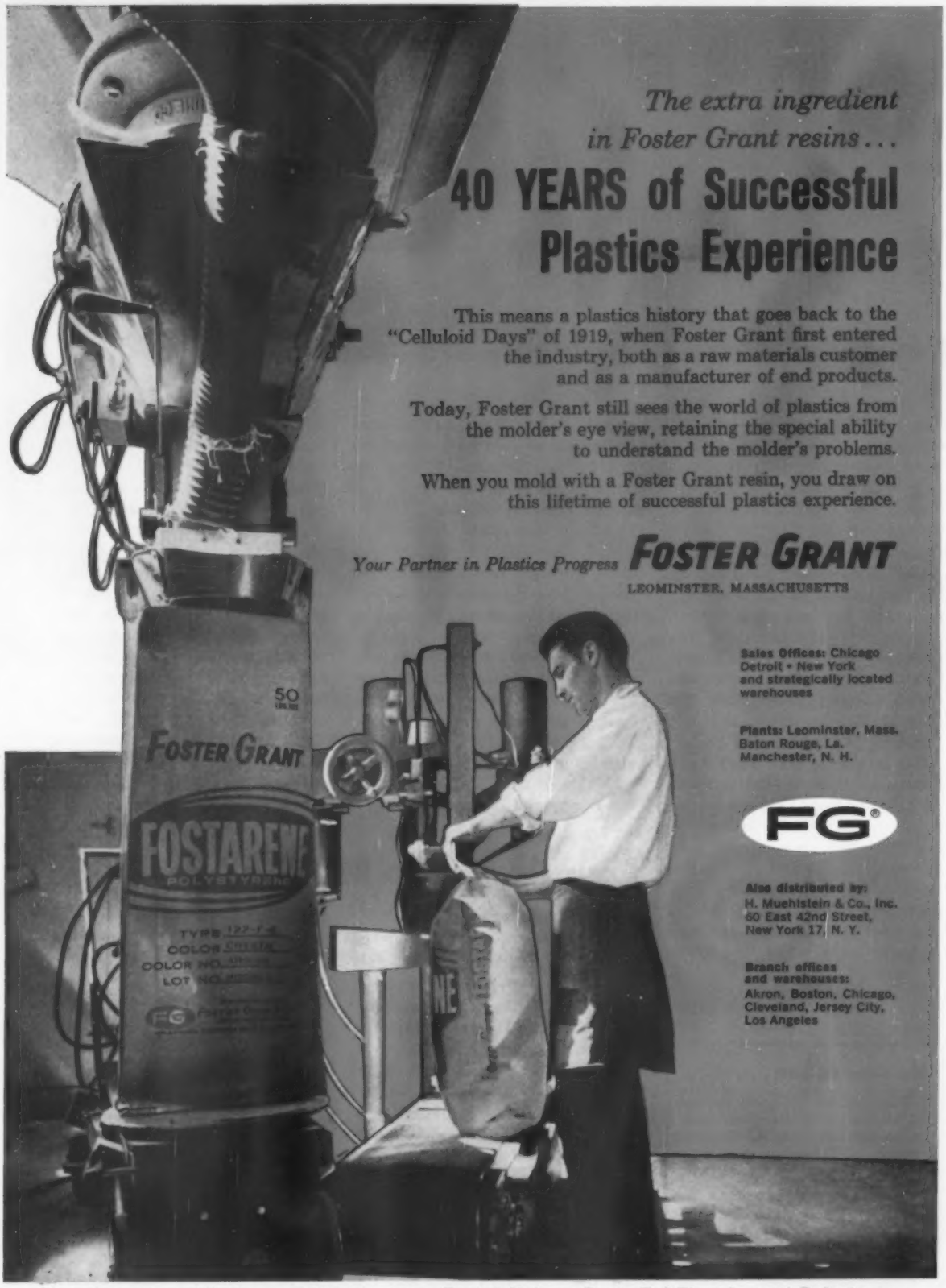
**Society of Plastics Engineers** (Apr 20, Fort Worth)—"Plastics in the Petroleum and Chemical Industries" is the subject of a special one-day technical conference sponsored by the North Texas Section of SPE. Papers will be presented on recent developments in surface coatings and plastics structures.

Specific papers on plastics structures: fabricated thermoplastic structures, thermoplastic piping, corrosion resistant equipment for the chemical industry, applications for high density polyethylene, and reinforced plastics in the chemical industry.

Papers on surface coatings: surface preparation for metals, catalyzed coatings in the oil industry, films for coastal and marine atmospheres, internal coatings, and "Parlon" in chemical resistant maintenance coatings.

**American Foundrymen's Society** (May 9-13, Philadelphia) — An emphasis on new developments and concepts will highlight the 1960 AFS Castings Congress and Exposition.

Among the new developments to be shown and discussed are: "uncanny" means of testing for

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quality control; improvements in nondestructive testing methods; and a broad array of new and improved materials for dry and green sand molding, core making, shell molding and pattern making.

**American Society of Mechanical Engineers** (May 23-26, New York)—As usual, the Design Engineering Conference sponsored by ASME's Machine Design Div. will be held in conjunction with Clapp & Poliak's Design Engineering Show. Both will concentrate on the application of space age design theory and techniques to both advanced space uses and home and factory products.

The first day's Conference session will be devoted to "New Horizons in Engineering Design"—a panel discussion on how new design principles, relationships and formulas developed for nuclear and space technology can be applied to commercial products. Special attention will be given to high and low temperatures, erosion, corrosion, impact, vibration, miniaturization, reliability, and limited life.

Other topics to be covered: new welding processes, fabrication by explosives, characteristics of high strength steels, and composite materials. (For complete details on registration, technical program and exhibitors, see next month's issue of M/DE.)

**Metallurgical Society, AIME** (May 26-27)—New developments in metalworking will be covered in three technical sessions to be presented at AIME's 14th New England Regional Conference. Papers will cover high speed forming, extrusion and special forming procedures. Each session will be prefaced by a review of the theory involved.

### *Army Sets Up Plastics Center*

A Plastics Technical Evaluation Center (PLASTEC) has been established at Picatinny Arsenal by the Dept. of Defense.

The Center, operated by the Army Ordnance Corps, will collect, evaluate, store and disseminate technical information on current development, engineering and application work being conducted on plastics, including reinforced plastics. It will also try to stimulate advances in standardization of processes, products, testing methods and materials. Principal areas of concentration will be electrical, mechanical and structural.

Information disseminated through PLASTEC will be made available to the public through the Office of Technical Services, Dept. of Commerce, Washington 25, D. C.

## New Uses of Reinforced Plastics Revealed

A lightweight shotgun using a reinforced plastics barrel was one of the highlights of the recent, well-attended 15th annual conference of the Reinforced Plastics Div. of the Society of the Plastics Industry.

Of the more than 75 papers presented, about 25 described where, why and how reinforced plastics are being specified for military and industrial applications.

**Barrel is 30-50% lighter**

The shotgun barrel, described by J. W. Silva, Winchester-Western Div., Olin Mathieson Chemical Corp., consists of a filament-wound glass fiber-epoxy structure with a thin metal liner on the inside. The barrel weighs about 30-50% less than conventional steel barrels, yet has better strength.

Other subjects of interest were: the use of reinforced plastics in extreme high temperature missile environments (Raech, Norair; Haugen, Chrysler; Mobilia and Rosato, Raytheon; Cutler and Brown, H. I. Thompson); installation and design considerations in the use of reinforced plastics in submarine and torpedo structures (Buer, Mare Island Naval Shipyard; Murry and Veranda, U. S. Naval Ordnance Test Station); and the use of reinforced plastics in transportation equipment, including a 20-ton cargo carrier made of glass-epoxy sandwich panels (Buber and Hawkins, Union Carbide).

**Salt mandrel for filament winding**

Notable among the papers describing the design and fabrication of reinforced plastics was the one on the use of a salt mandrel for filament winding (Yates and McCarthy, Brunswick-Balke-Collender). Because the structure to be wound was hollow, removal of the mandrel caused problems. But a

*(continued on p 184)*

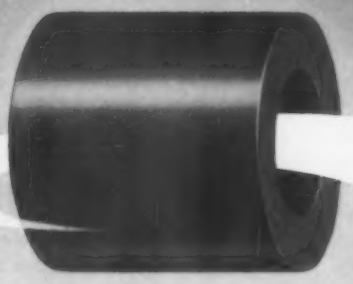
## Automotive Engineers Discuss Adhesives

Use of adhesives in automobile construction, new engineering materials, corrosion problems, case hardening of steels, and suspension systems were among the more important subjects covered at the Society of Automotive Engineers' recent National Automobile Meeting.

Applications of high temperature gas carburizing and testing techniques were also covered.

**Coming Meetings on next page; more News on p 184**

# HYDRO-AIRE specifies MORGANITE



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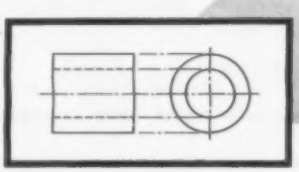

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## News OF INDUSTRY

### *Coming Meetings*

AUTOMOTIVE CONFERENCE, Society of the Plastics Industry, Inc., Cellular Plastics Div. Detroit. Apr 20-21.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 3rd annual Fluorocarbons Div. meeting. New Orleans. Apr 20-22.

SOUTHWEST METALS & MINERALS CONFERENCE, American Institute of Mining, Metallurgical and Petroleum Engineers. Los Angeles. Apr 21-22.

1960 POWDER METALLURGY SHOW AND MEETING, Metal Powder Industries Federation. Chicago. Apr 25-27.

41ST ANNUAL CONVENTION AND WELDING EXPOSITION, American Welding Society, Inc. Los Angeles. Apr 25-29.

SYMPOSIUM ON MATERIALS PROBLEMS IN SPACE FLIGHT SYSTEMS, Cincinnati, Dayton, Columbus Chapters, American Society for Metals. Cincinnati. Apr 27-28.

2ND SOUTHWESTERN METAL EXPOSITION AND CONGRESS, American Society for Metals. Dallas. May 9-13.

1960 CASTINGS CONGRESS AND EXPOSITION, American Foundrymen's Society. Philadelphia. May 9-13.

PRODUCTION ENGINEERING CONFERENCE, American Society of Mechanical Engineers. Milwaukee, Wis. May 17-19.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, 1960 national spring meeting. Indianapolis. May 18-20.

DESIGN ENGINEERING CONFERENCE, Machine Design Div., ASME. New York City. May 23-26.

DESIGN ENGINEERING SHOW, New York City. May 23-26.

REFRACTORY MATERIALS AND ALLOYS SYMPOSIUM, AIME. Detroit. May 25-26.

NEW ENGLAND REGIONAL CONFERENCE ON NEW DEVELOPMENTS IN METALWORKING, Metallurgical Society, AIME. Boston. May 26-27.

AMERICAN NUCLEAR SOCIETY, 6th annual meeting. Chicago. June 12-16.

1ST INTERNATIONAL POWDER METALLURGY CONFERENCE, Metal Powder Industries Federation and Institute of Metals Div., Metallurgical Society of AIME. New York City. June 13-15.

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. . . the new, fast-selling BVI* electric can opener is an eye opener for the potential customer, both in performance and in appearance. This versatile appliance, at a single touch on the control bar, automatically grips, punctures, turns and opens the can . . . then shuts itself off while a ceramic magnet lifts the severed lid away, leaving a smooth rolled edge that is perfectly safe to handle.

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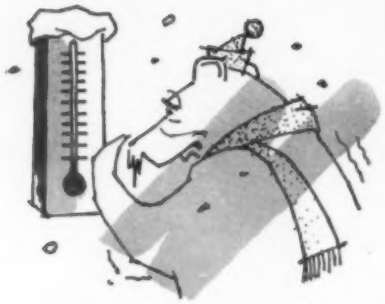
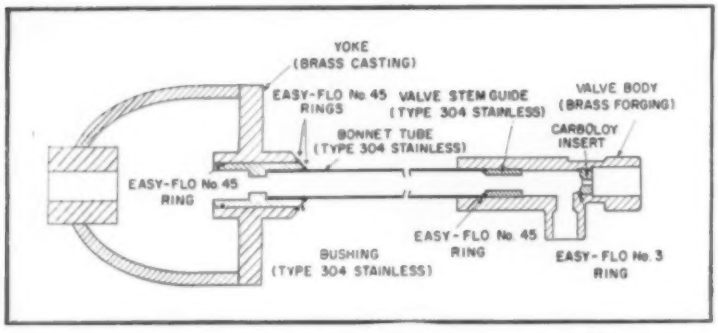
*Don't Worry About Joint Strength At Sub Zero Temperatures . . .*



# EVEN AT MINUS 300F HANDY & HARMAN SIL-FOS AND EASY-FLO BRAZED JOINTS ARE VERY STRONG




*Six-Piece Expansion Valve Assembly For Air Separator Joined In One Operation:* Drawing of valve assembly shows locations of 5 preplaced rings of EASY-FLO 3 and EASY-FLO 45.

The need for strong, tight joints for ultra cold service—in rocketry, cold treating and refrigeration of all types—becomes more and more critical.

Recent low temperature tests with Handy & Harman's silver brazing alloys SIL-FOS and EASY-FLO on deoxidized copper lap joints show impressive joint strength.

At minus 321°F, the joint strength (in psi) of EASY-FLO 45 is 30,100 lbs. At the same temperature, the psi of a SIL-FOS brazed joint is 21,900 lbs. These strengths represent the average of four tests with each alloy; HANDY FLUX was used in each test.

A current "sub-zero" example is Air Products, Inc., Allentown, Penn. This company makes an air separator which produces tonnage quantities of oxygen and/or nitrogen for industrial use. The separator's components consist of Type 304 stainless steel, cast bronze, brass, copper, copper bronze and Carboloy. Joint sizes range from less than ¼ inch to 54 inches in diameter. In operation the separator is exposed to temperatures of minus 300°F and pressures approaching 5000 psi. To join this complex assembly, Air Products uses Handy & Harman's EASY-FLO 35, EASY-FLO 3 and EASY-FLO 45 and HANDY FLUX.

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**FOR A GOOD START: BULLETIN 20**

This concise bulletin introduces you to silver alloy brazing—gives joining methods and joint design as well as economies that exist with EASY-FLO brazing. Just ask, we'll be pleased to send you a copy.

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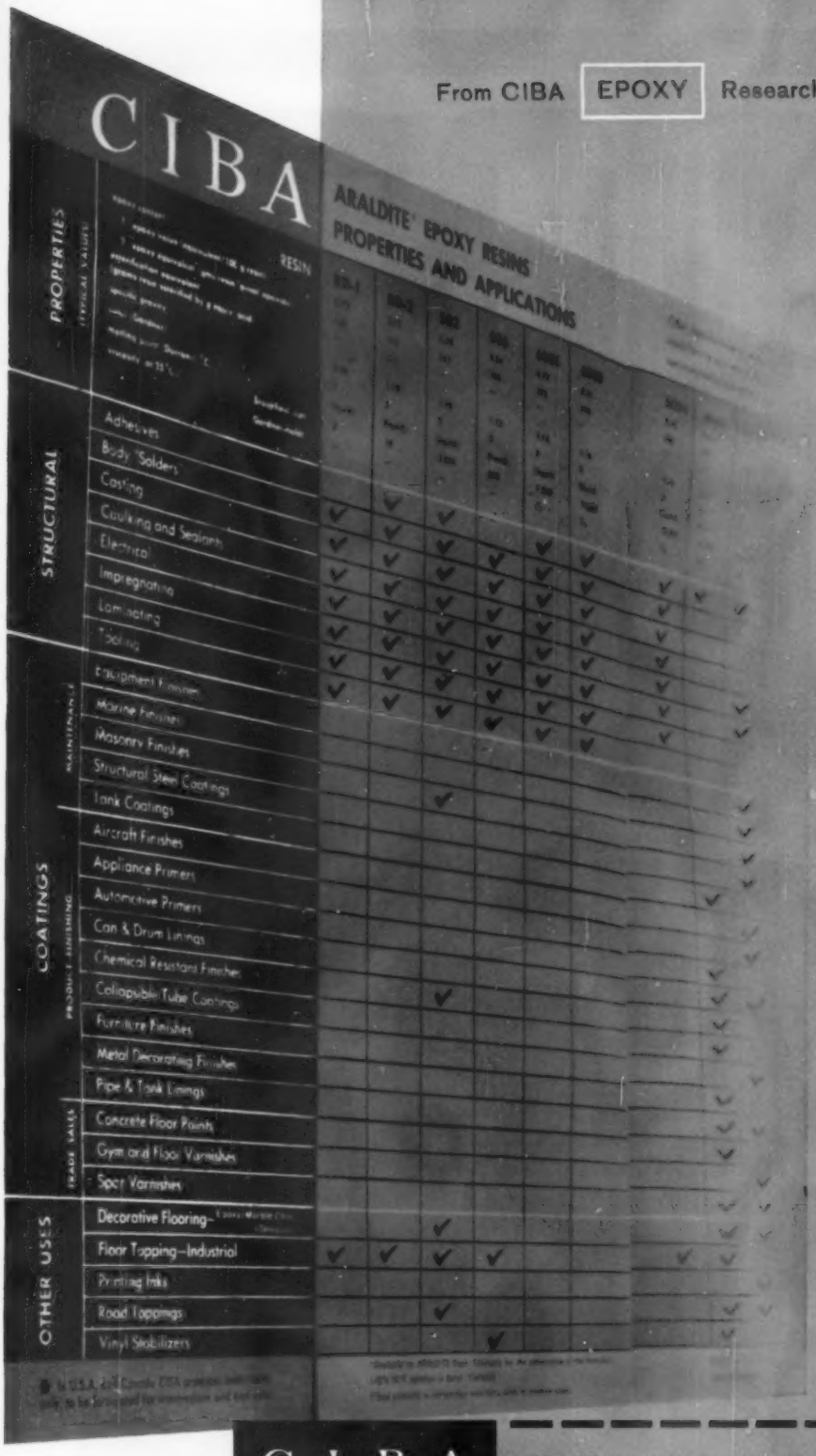
From CIBA **EPOXY** Research...




## A LONG VIEW ON RESINS DEVELOPMENTS

The many ways in which CIBA Araldite® Epoxy Resins are used today point up one basic fact that should be of primary interest to all concerned with product development. The greatest era of usefulness for these versatile resins is still ahead! Continuous study of the accelerated developments in the field by CIBA world-wide research is providing knowledge about epoxy resins properties and applications as objective as it is practical. It is the basis of all CIBA Technical Service to users and potential users of epoxy resins. "The Epoxy Building Block," a new CIBA Araldite Epoxy Resin booklet, contains detailed properties and application data covering each resin. This booklet may be obtained without obligation by returning the coupon below to CIBA Products Corporation, Fair Lawn, New Jersey.

✔ Shown here is a section of the 1960 Edition CIBA Araldite Epoxy Resins Properties and Applications Chart contained in the booklet "The Epoxy Building Block." It is a handy cross-reference source of latest information on epoxy resins for practical use in planning new product development and present product improvement.

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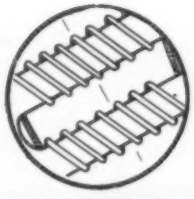
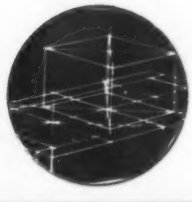
# 1960 ENGIN SHOW





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**For information, write to Clapp & Poliak, Inc., Show Management, 341 Madison Avenue, New York 17, New York.**

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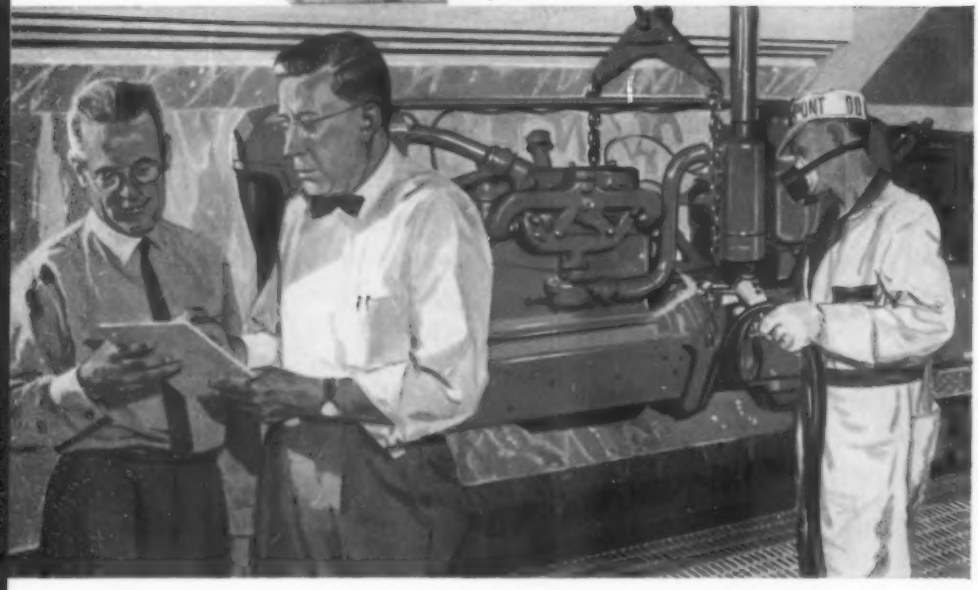
**NEW MODEL TRACTOR,** one of the new Allis-Chalmers line, has many comfort and convenience features, improved transmission, choice of 3 fuel systems. Long periods of exposure are no threat to the baked-on "Dulux" finish. It resists chipping, peeling, temperature extremes . . . retains a rich gloss despite sunlight and weathering . . . stays new-looking, attractive.



**CHECK OF SPRAY LINE** by Muir L. Frey, Assistant to the General Works Manager, Tractor Group, and Ken Rogers, Du Pont salesman, is typical of the close cooperation that has kept the finishing operation at a high level of efficiency. Note operator sprays all of the conveyorized tractor assembly with "Dulux," including the engine.

*Du Pont Finishes Service Package* — **FORMULATION, APPLICATION,**

# ALLIS-CHALMERS gets more "yield" from the tractor field with Du Pont DULUX® Enamel

- Distinctive Persian orange "Dulux" identifies Allis-Chalmers tractors at a glance
- Durable "Dulux" keeps its showroom look, "takes the place of indoor storage"
- Du Pont's help in developing an efficient finishing line is typical of the cooperation you can expect

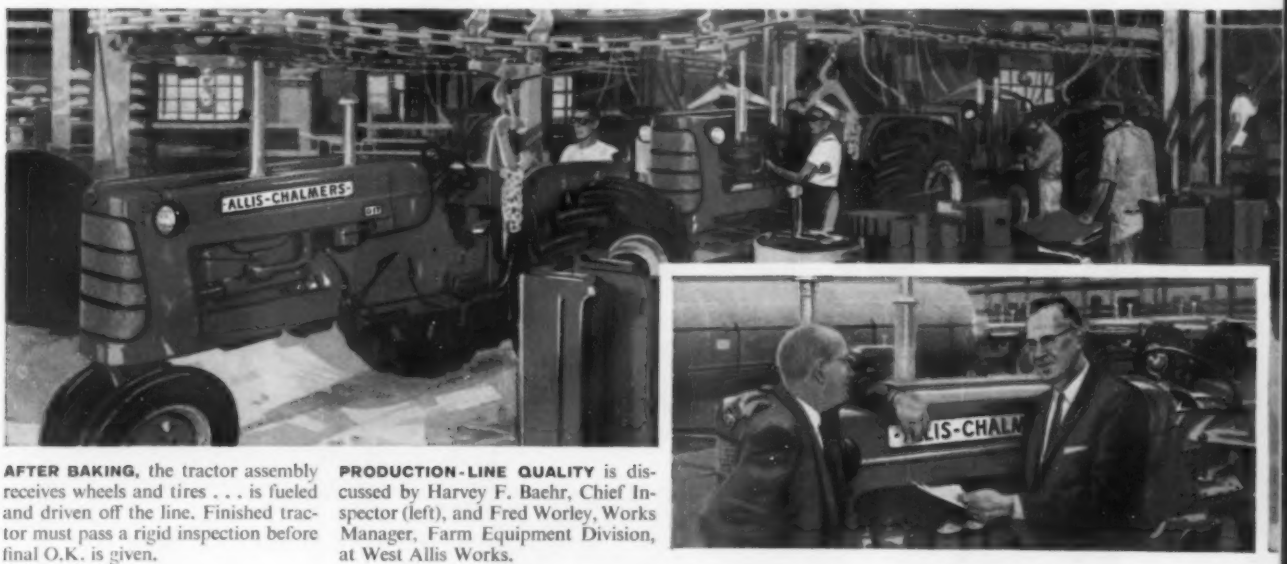
Allis-Chalmers Manufacturing Co. knows that a smart showroom look is a necessary sales feature for today's farm tractors. A Du Pont finishes program has helped achieve this benefit *consistently*—using high-gloss "Dulux" Enamel in Allis-Chalmers, identifying Persian orange color.

Du Pont has worked with Allis-Chalmers for 25 years in establishing efficient spray lines tailored to the production needs of the day. Frequent checks of color standards, "Dulux" formulations and spraying techniques have kept the operation smooth, trouble-free. The result—a gleaming, durable finish that has pleased Allis-Chalmers customers for years.

Like Allis-Chalmers, most manufacturers can benefit when experienced Du Pont personnel work with them to assure efficient use of industrial finishes. Here is experience in *depth* . . . not only from technically trained Du Pont salesmen and service men, but also from the field service laboratories of the world's foremost paint research organization.

Du Pont specialists have the background and know-how needed to apply finishes by any method, in practically any industry. They'll recommend a finishes system that can solve your particular problem . . . work with your personnel on a continuing basis. Best of all, *they can help you develop better finishing at lower costs!*

If finishing is a key part of *your* production, it will pay you to see a Du Pont representative. Call or write: E. I. du Pont de Nemours & Co. (Inc.), 2498 Nemours Building, Wilmington 98, Delaware.




**AFTER BAKING,** the tractor assembly receives wheels and tires . . . is fueled and driven off the line. Finished tractor must pass a rigid inspection before final O.K. is given.

**PRODUCTION-LINE QUALITY** is discussed by Harvey F. Baehr, Chief Inspector (left), and Fred Worley, Works Manager, Farm Equipment Division, at West Allis Works.

**FOLLOW-THROUGH** — *Sets Today's Production Pace*

DU PONT
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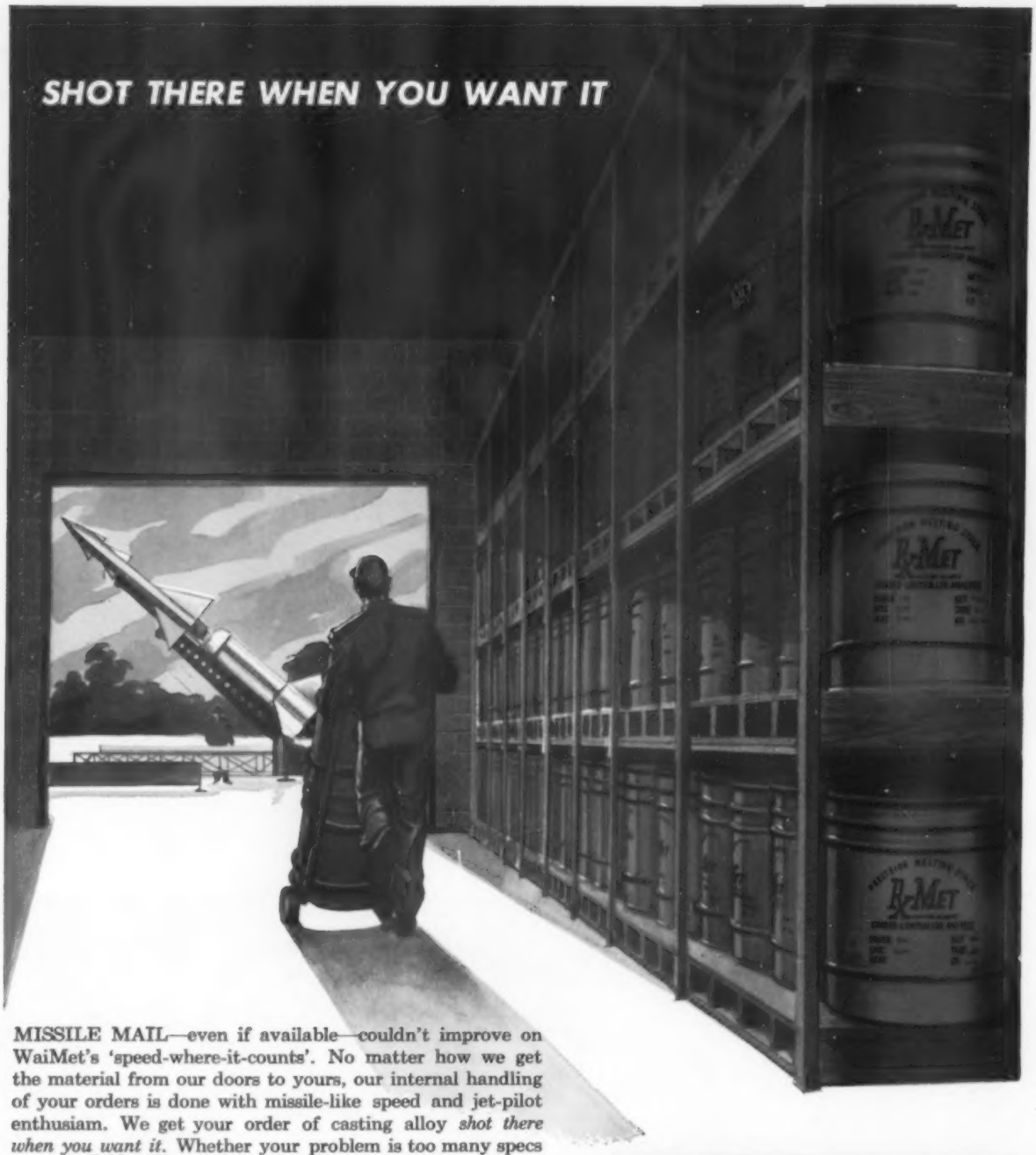


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- National Vulcanized Fibre has outstanding arc resistance, low thermal conductivity, amazing resiliency and shock-absorbency, high abrasive resistance. It is fungus resistant. It soaks up noise!
- National Fibre can be formed or deep-drawn into intricate shapes; and machined, polished, painted, lacquered, embossed . . . even used in combination with other materials, such as aluminum, wood, rubber, copper.
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- *This* could be the plastic you are looking for now!

For help on a present problem, or for information on National Vulcanized Fibre and samples, just write Dept. RR, or contact your nearby NVF Sales Office. You'll find the 'phone number in Sweet's Product Design File 2b/Na.

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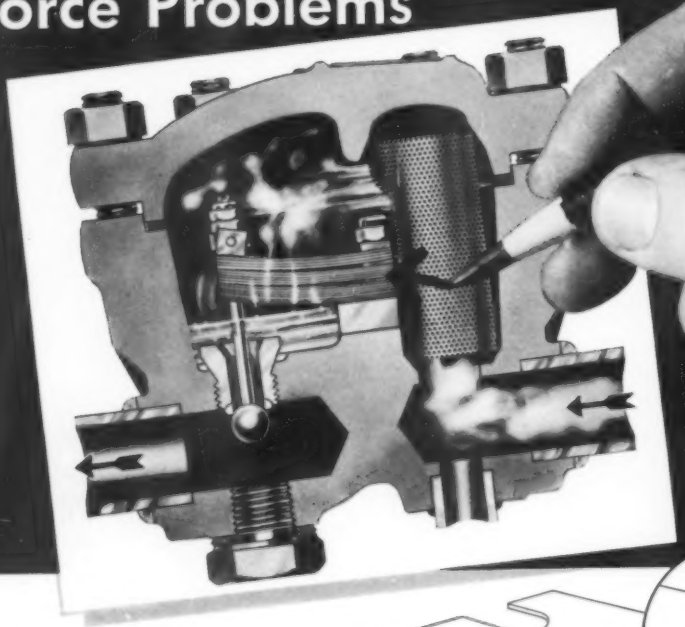

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## *. . . Increases efficiency and sensitivity*

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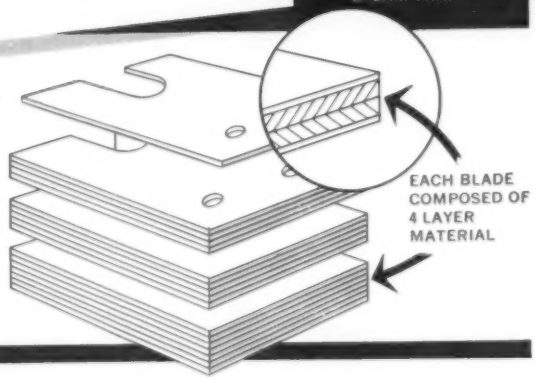


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| 9 | 34 | 59 | 84 | 109 | 134 | 159 | 184 | 209 | 234 | 259 | 284 | 309 | 334 | 359 | 384 | 409 | 434 | 459 | 484 | 509 | 534 | 559 | 584 | 609 | 634 | 659 | 684 |
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| 13 | 38 | 63 | 88 | 113 | 138 | 163 | 188 | 213 | 238 | 263 | 288 | 313 | 338 | 363 | 388 | 413 | 438 | 463 | 488 | 513 | 538 | 563 | 588 | 613 | 638 | 663 | 688 |
| 14 | 39 | 64 | 89 | 114 | 139 | 164 | 189 | 214 | 239 | 264 | 289 | 314 | 339 | 364 | 389 | 414 | 439 | 464 | 489 | 514 | 539 | 564 | 589 | 614 | 639 | 664 | 689 |
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| 16 | 41 | 66 | 91 | 116 | 141 | 166 | 191 | 216 | 241 | 266 | 291 | 316 | 341 | 366 | 391 | 416 | 441 | 466 | 491 | 516 | 541 | 566 | 591 | 616 | 641 | 666 | 691 |
| 17 | 42 | 67 | 92 | 117 | 142 | 167 | 192 | 217 | 242 | 267 | 292 | 317 | 342 | 367 | 392 | 417 | 442 | 467 | 492 | 517 | 542 | 567 | 592 | 617 | 642 | 667 | 692 |
| 18 | 43 | 68 | 93 | 118 | 143 | 168 | 193 | 218 | 243 | 268 | 293 | 318 | 343 | 368 | 393 | 418 | 443 | 468 | 493 | 518 | 543 | 568 | 593 | 618 | 643 | 668 | 693 |
| 19 | 44 | 69 | 94 | 119 | 144 | 169 | 194 | 219 | 244 | 269 | 294 | 319 | 344 | 369 | 394 | 419 | 444 | 469 | 494 | 519 | 544 | 569 | 594 | 619 | 644 | 669 | 694 |
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| 15 | 40 | 65 | 90 | 115 | 140 | 165 | 190 | 215 | 240 | 265 | 290 | 315 | 340 | 365 | 390 | 415 | 440 | 465 | 490 | 515 | 540 | 565 | 590 | 615 | 640 | 665 | 690 |
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| 20 | 45 | 70 | 95 | 120 | 145 | 170 | 195 | 220 | 245 | 270 | 295 | 320 | 345 | 370 | 395 | 420 | 445 | 470 | 495 | 520 | 545 | 570 | 595 | 620 | 645 | 670 | 695 |
| 21 | 46 | 71 | 96 | 121 | 146 | 171 | 196 | 221 | 246 | 271 | 296 | 321 | 346 | 371 | 396 | 421 | 446 | 471 | 496 | 521 | 546 | 571 | 596 | 621 | 646 | 671 | 696 |
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| 24 | 49 | 74 | 99 | 124 | 149 | 174 | 199 | 224 | 249 | 274 | 299 | 324 | 349 | 374 | 399 | 424 | 449 | 474 | 499 | 524 | 549 | 574 | 599 | 624 | 649 | 674 | 699 |
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**Suppliers' Literature**

**Books, p 178**

**Reports, p 182**

# TECHNICAL LITERATURE

## *Suppliers' New Bulletins*

**Stainless Steel Tubing.** Allegheny Ludlum Steel Corp., 34 pp, illus. Sizes, grades, design data, corrosion resistance, and uses of welded and seamless stainless steel tubing. (1)

**Electroforming.** Allied Record Mfg. Co., Allied Research & Engineering Div., 34 pp, illus. Information on the electroforming process, design practices, test results, and typical applications. (2)

**Seamless Tubing.** Babcock & Wilcox Co., Tubular Products Div., 6 pp, No. TDC-193. General characteristics, machinability, heat treatment, and other technical data on two grades of steel seamless tubing. (3)

**Coloring Plastics.** Bee Chemical Co., Logo Div., 16 pp. Information on the advantages of painting thermoplastic parts as opposed to molding-in color. (4)

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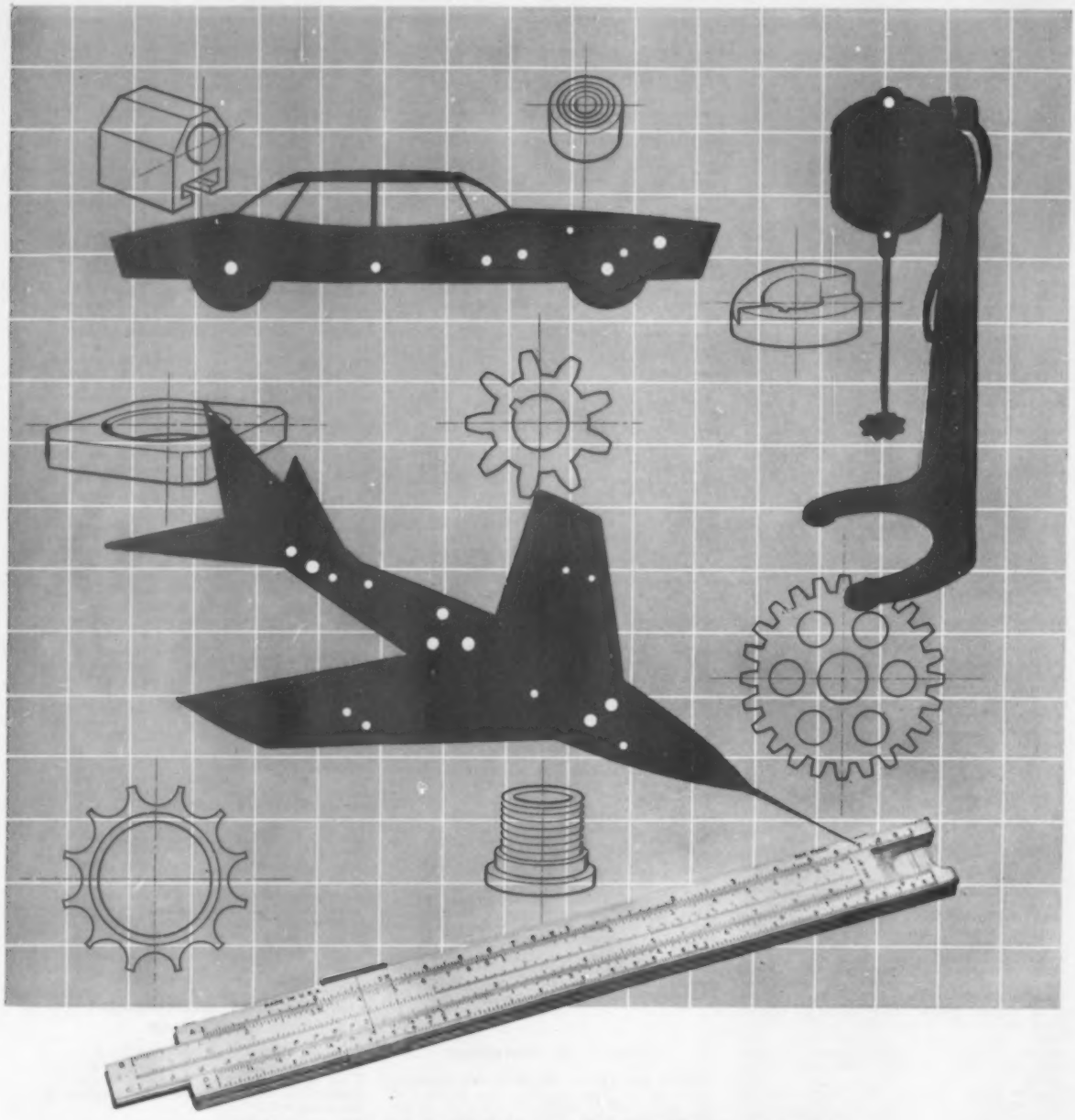

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# 16th Annual MPIF Meeting

**April 25-27, 1960**

The 16th annual meeting of the Metal Powder Industries Federation is set for Apr 25-27 at the Drake Hotel, Chicago. Running concurrently with the meeting will be the 1960 Powder Metallurgy Show. A special event at this year's meeting is the "Powder Metallurgy Parts Seminar."

### The meeting

This year's technical sessions will feature 17 papers on various aspects of powder metallurgy and metal powder parts, and a special session on electronic cores. The technical sessions will run from 9 a.m. to 4 p.m. on Tuesday, Apr 26, and from 9 a.m. to 2 p.m. on Wednesday, Apr 27. The special session on electronic cores will be held on Tuesday, from 9:15 a.m. to noon. All technical sessions will be held in the Drake Hotel's Grand Ballroom and Gold Coast Room.

As in the past, the Federation's business sessions will take place during the first day of the meeting, Monday, Apr 25. A reception and banquet will be held Tuesday evening.

### The seminar

The powder metallurgy parts seminar is designed to give engineers, designers and management a first-hand opportunity to find out what is being done with powder metallurgy today and what advantages it may have to offer them. The seminar will consist of displays, technical literature, an open forum discussion using actual case histories as a basis, and a visit to the Show. Registration is free.

### The show

Company exhibits will be open from 8:30 a.m. to 6:00 p.m. on both Tuesday and Wednesday.

Exhibits will include new sintering furnaces, compacting presses, pulverizing mills and other equipment, as well as various metal powders and fabricated parts.

## Program

### Monday, April 25

Business Meetings

### Tuesday, April 26

*8:30 a.m.*

Powder Metallurgy Show exhibit opens.

*9:00-11:00 a.m.*

Chairman—Byron B. Belden, Baldwin-Lima-Hamilton Corp.

Co-Chairman—Peter V. Schneider, International Business Machines Corp.

**Ultrasonic Testing of Powder Metallurgy Parts**—E. H. Abbe and R. D. Korytoski, Springfield Armory

**Machinability of Sintered Iron**—R. S. Jamison and E. Geijer, Hoeganaes Sponge Iron Corp.

**Basis for Nondestructive Testing of Cemented Carbide**—W. O. Woods, Watertown Arsenal

**Process Controls for Quality and Quantity in Powder Metallurgy Parts Production**—W. R. Anderson, Maytag Co.

**Checking Density Variations in Powder Metallurgy Parts by Means of Eddy Currents**—R. Kenton, Magnaflux Corp.

*9:00-11:00 a.m.* Special session on Electronic Cores

Chairman—B. J. Falk, Arnold Engineering Co.

Co-Chairman — W. E. Cairnes, Radio Cores, Inc.

**The Testing of Magnetic Powders for Electronic Core Applications**—T. A. Dunton, Mond Nickel Co., Ltd., England

**Contributions to the Evaluation of Magnetic Materials**—J. A. Roberts and G. Ludewig, General Aniline & Film Corp.

**An Equipment for Measuring the Temperature Coefficient of Permeability of Powder Cores**—T. A. Dunton, Mond Nickel Co., Ltd.

*2:00-5:00 p.m.*

Chairman—Carl G. Johnson, Presmet Corp.

Co-Chairman—Norbert K. Koebel, Lindberg Engineering Co.

**The Effect of Powder Particle Size Distribution on the Sintering of Molybdenum**—A. R. Poster and C. T. Waldo, Sylvania Electric Products, Inc., and H. H. Hausner, Consultant

**Chic Sale Looks at Powder Metallurgy**—W. R. Toeplitz, Bound Brook Oil-Less Bearing Co.

**Heat Treatable Steel Bonded Carbides—New Construction Materials for Tools and Wear Resistant Components**—J. L. Ellis, Sintercast Div., Chromalloy Corp., and E. Gregory, Air Reduction Co., Inc.

**Sintered Nickel Steels—The Path to Improved Properties**—W. V. Knopp, S-K-C Research Assoc.

**A Look at Dispersion Strengthening by Powder Metallurgy Methods**—N. J. Grant, Massachusetts Institute of Technology

*6:30 p.m.*

Reception and Banquet

### Wednesday, April 27

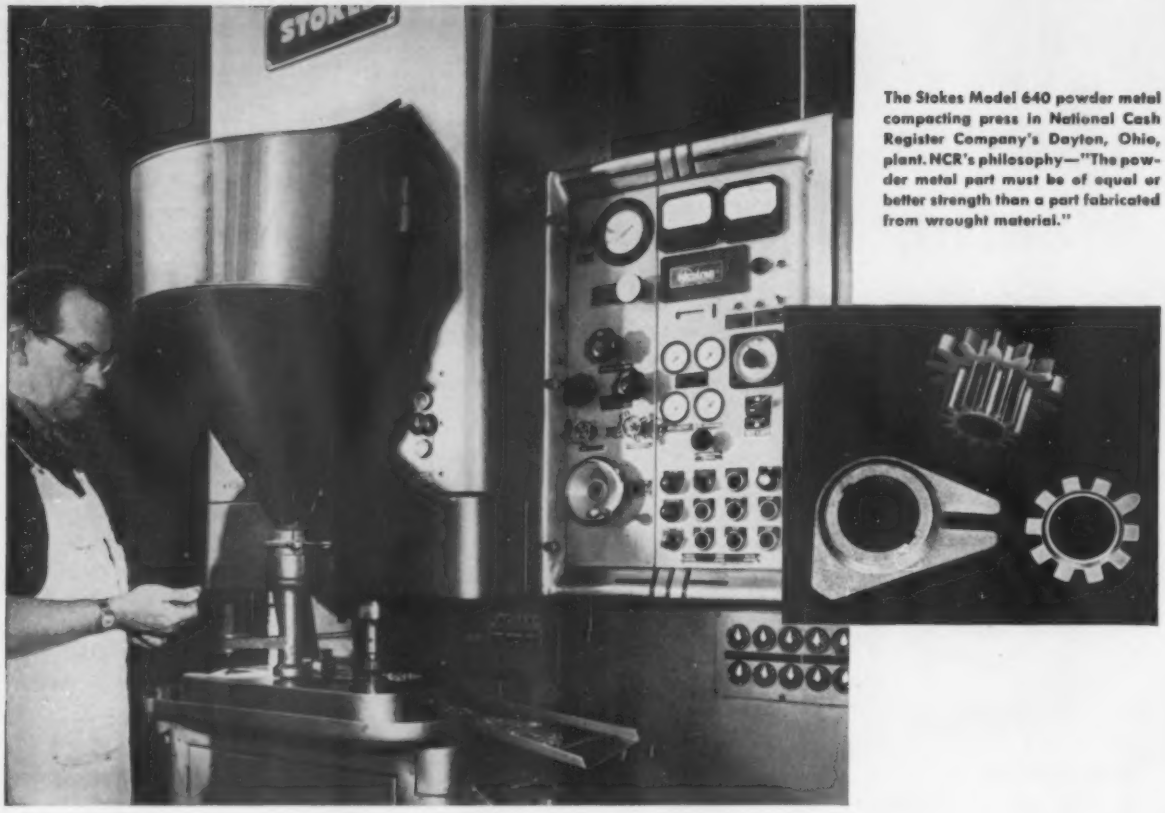
*8:30 a.m.*

Powder Metallurgy Show exhibit opens

*9:00-11:00 a.m.*

Chairman—E. Lowe, Greenback Industries, Inc.

Co-Chairman—V. T. Price, Jr., Pyron Corp.



The Stokes Model 640 powder metal compacting press in National Cash Register Company's Dayton, Ohio, plant. NCR's philosophy—"The powder metal part must be of equal or better strength than a part fabricated from wrought material."

# National Cash Register rings up savings through powder metallurgy...

The Stokes Model 640 50-ton powder metal press, at the Dayton, Ohio, plant of National Cash Register Company, has proved a valuable tool in the production of precision gears and parts for cash registers and accounting machines. In 1957, over 250 different high-density parts were made by powder metallurgy—in early '58, 47 additional parts went into production.

The economic benefits of this process have also been proved. A cost analysis of 54 parts shows substantial savings per year through lower direct labor costs in machining and inspection. More complex parts are continually being introduced—parts with hubs, steps, and thin projections—made possible by press equipment such as the Stokes 640.

The Stokes Model 640 offers up to five press motions with independently adjustable compression, fill and ejection points . . . each with direct reading position indicators calibrated to .001". This set-up versatility is teamed with operating simplicity that enables economical long or short runs, and permits easy re-runs of jobs on which set-up standards have been established.

Investigate the proved potential of powder metal pressing . . . not only for ways to cut costs and save metal over conventional machining, but also for ways to get properties of metals, alloys and mixtures not attainable by other techniques. Ask for a production and economic analysis on your own parts. Stokes' facilities include sample production, punch and die design and fabrication, and operator instruction. Stokes Engineering Advisory Service is ready to serve your powder metallurgy needs, whether large or small.

See us at the Powder Metallurgy Show—Booth 1 & 2—Drake Hotel—Chicago—April 25-27

*Powder Metal Press Division*
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

**STOKES**

For more information, turn to Reader Service card, circle No. 420

## POWDER METALLURGY PREVIEW *continued*

**Application of Stainless Steel Powder Metallurgy**—W. L. Batten, Vanadium-Alloys Steel Co.

**Application Engineering Applied to Powder Metallurgy**—R. B. Thomson, U. S. Graphite Co.

**Low Temperature Impact Strength of Sintered Steels**—L. Menezes, Picatinny Arsenal

**Aircraft Superalloys by Powder Metallurgy**—M. W. Toaz, G. F. Davies and R. D. Johnson, Clevite Corp.

**Nickel-Coated Composite Powders — Compacting and Sintering Characteristics**—J. A. Lund, T. Krantz and V. E. Mackiw, Sherritt Gordon Mines Ltd.

*2:00 p.m.*

**The Outlook for Metal Powders and Powder Metallurgy**—K. H. Roll, MPIF

**1960 International Powder Metallurgy Conference—A Preview**—F. V. Lenel, Renssalaer Polytechnic Institute

## Exhibitors

| | Booth |
|---|---|
| Alan Wood Steel Co. | 14, 17 |
| Associated Equipment Co. | 3 |
| Baldwin-Lima-Hamilton Corp. | 19 |
| Chicago Powdered Metal Products Co. | 4 |
| Cleveland Tool & Die Co. | 23 |
| Coulter Industrial Sales Co. | 35 |
| Crane Co., Metals Div. | 10, 11 |
| Dorst Div., Arnhold Ceramics, Inc. | 29 |
| Drever Co. | 30 |
| General Machine Co. of New Jersey | 15 |
| Harper Electric Furnace Corp. | 13 |
| Charles Hardy, Inc. | 26 |
| Hoeganaes Sponge Iron Corp. | 18 |
| Ipsen Industries, Inc. | 7 |
| A. Johnson & Co., Inc. | 31 |
| Joseph Dixon Crucible Co. | 9 |
| Kux Machine Co. | 33 |
| Lindberg Engineering Co. | 25 |
| MATERIALS IN DESIGN ENGINEERING | 12 |
| Mannesmann-Meer, Inc. | 21, 22 |
| New Jersey Zinc Co. | 24 |
| Powdercraft Corp. | 16 |
| *Precision Metal Molding* | 34 |
| Republic Steel Corp. | 27, 28 |
| Sherritt Gordon Mines Ltd. | 5 |
| Southwestern Graphite Co. | 32 |
| F. J. Stokes Corp. | 1, 2 |
| U. S. Graphite Co. | 6 |
| Vanadium-Alloys Steel Co. | 20 |
| Witco Chemical Co., Inc. | 8 |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# WHAT IS "FERNLOCK"?

"Fernlock" is a dendritic copper powder offering a hard to get combination of properties not found in either flake or granular copper powders. Check these special features. Fernlock may be just the material you need for that special problem.

1. High Purity (99.50% Min.)
2. Low Density (1.1 gr/cc Max.)
3. Fine Mesh Size (75% through 325)
4. Dendritic Particle Structure (See Photo—250 diameters)
5. Very High Green Strength (The particles interlock under pressure)

## MALONE METAL POWDERS, INC.

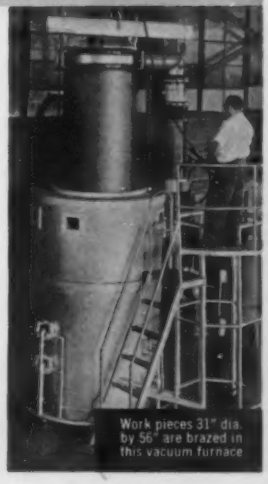
Route 202
Flemington, New Jersey
Phone: WIsconsin 7-7250

## Ask for Special Help When Brazing Stainless

Ask us for help in deciding how to best braze your stainless alloy assemblies. We successfully braze almost every known stainless steel, superalloy, and aluminum or titanium bearing metal.

Ask us to choose the best brazing alloy from the massive array of copper, silver, and nickel base alloys available. We know and use them all.

Ask us for a quotation on doing your stainless brazing or heat processing. Our pencils are sharp and so are the four furnace plants we operate to serve you.




**WALL COLMONOY CORPORATION**
**Stainless Processing Division**
*19345 John R Street • Detroit 3, Michigan*
*Wall Colmonoy furnace plants are maintained in Michigan, Pennsylvania, Ohio, and California*

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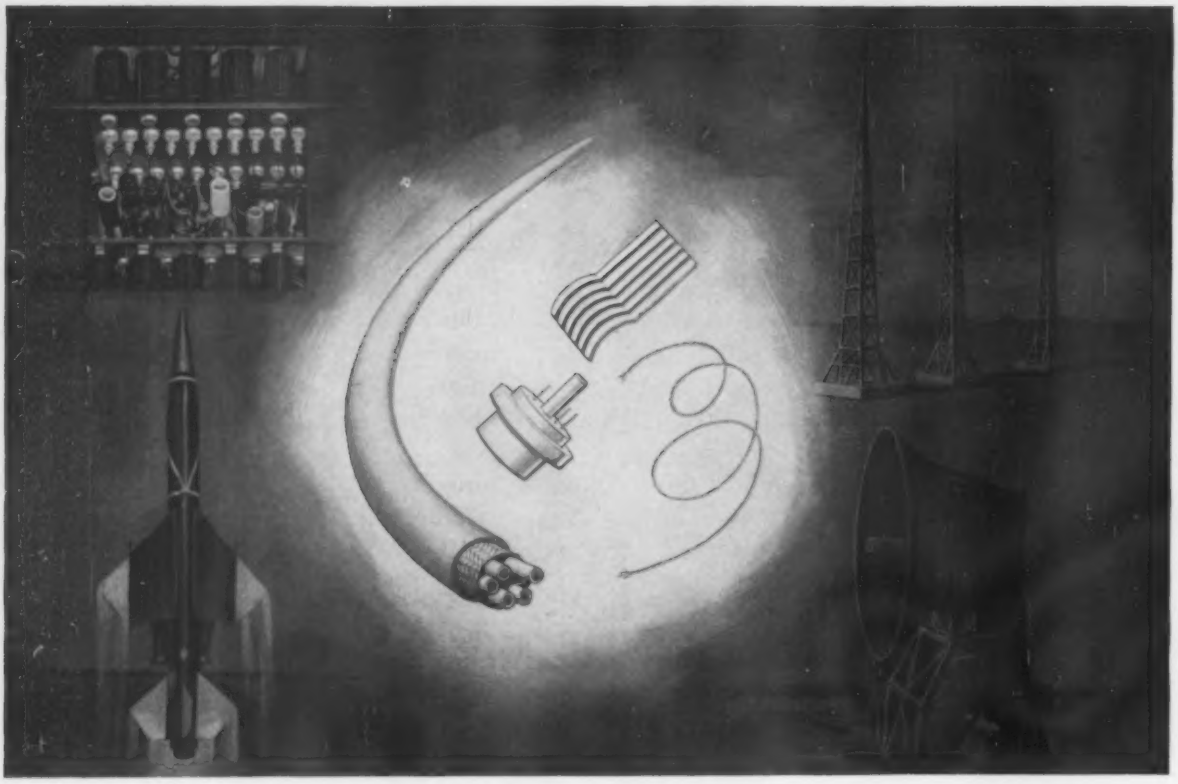


*NOW COMMERCIALLY AVAILABLE—*

# New TEFLON® 100 FEP Resin...for a new wide range of improved component designs

With the commercial availability of TEFLON 100 FEP-fluorocarbon resin—a new, melt-processible fluorocarbon resin—the family of TEFLON resins now offers an outstanding combination of properties for use in a wider range of electrical and electronic equipment and molded components. TEFLON FEP resins can be molded and extruded by techniques commonly used with thermoplastic polymers. TEFLON FEP resin has unmatched electrical properties over a wide range of temperatures and frequencies. Parts fabricated from TEFLON FEP resin have excellent heat resistance . . . are capable of continuous service at temperatures up to 400°F. and higher under certain conditions. They are inert to virtually all chemicals and solvents. They have a very low coefficient of friction. They are tough, strong, and display excellent weatherability.

And because TEFLON FEP-fluorocarbon resin is melt-processible, it can be rapidly fabricated into complex shapes . . . extruded as jackets for wire and cable and as long, continuous lengths of wire insulation.

The new opportunities for improved design offered by TEFLON FEP resin are particularly important wherever there is a premium on the utmost reliability, simplified assembly, savings in weight and space through miniaturization. **For more information** about the properties and applications of TEFLON fluorocarbon resins, including additional data on the characteristics of the new FEP resin, write to us, mentioning your field of interest. Address: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.T-264, Room 2526, Wilmington 98, Delaware.

**In Canada:** Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

*TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.*

DU PONT REG. U.S. PAT. OFF.

TEFLON®
FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

For more information, turn to Reader Service card, circle No. 449

**KNOW YOUR ALLOY STEELS...**
*This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.*

# Quenching Media for Alloy Steels

In the quenching of alloy steels, several points require consideration, among them being the size and shape of the piece, the type of steel involved, the quenching medium, and proper agitation of the quenching bath.

The composition of the steel has an important bearing on the selection of a quenching medium. As an example: shallow-hardening steels require a fast cooling rate, whereas deeper-hardening steels require progressively slower rates as the alloy content increases.

Three commonly used types of quenching media for alloy steels are water, oil, and air. These are discussed below in the order of quenching severity:

**(1) WATER.** Since shallow-hardening steels require fast quenching rates, water is the quenching medium used to harden them. Agitation is generally used to help in obtaining the desired cooling rate. The use of brine solutions have proven beneficial when sufficient agitation cannot be obtained. It should be noted that the quenching rate drops as water temperature is increased. The range of 70 deg to 100 deg F is recommended.

**(2) OIL.** An oil quench cools more slowly than water, and faster than air. Oil-hardening steels can be hardened with less distortion and greater safety than water-hardening steels. Mineral oils are generally used because of their low cost and relatively stable nature.

**(3) AIR.** If sufficient alloying elements are present, critical cooling rates are decreased to the extent that certain steels can be quenched in either still or forced air.

While the choice of quenching medium is of prime importance, there is another factor that should not be overlooked. This is the agitation of the quenching bath. The more rapidly the bath is agitated, the more rapidly heat is removed from the steel, and the more effective the quench.

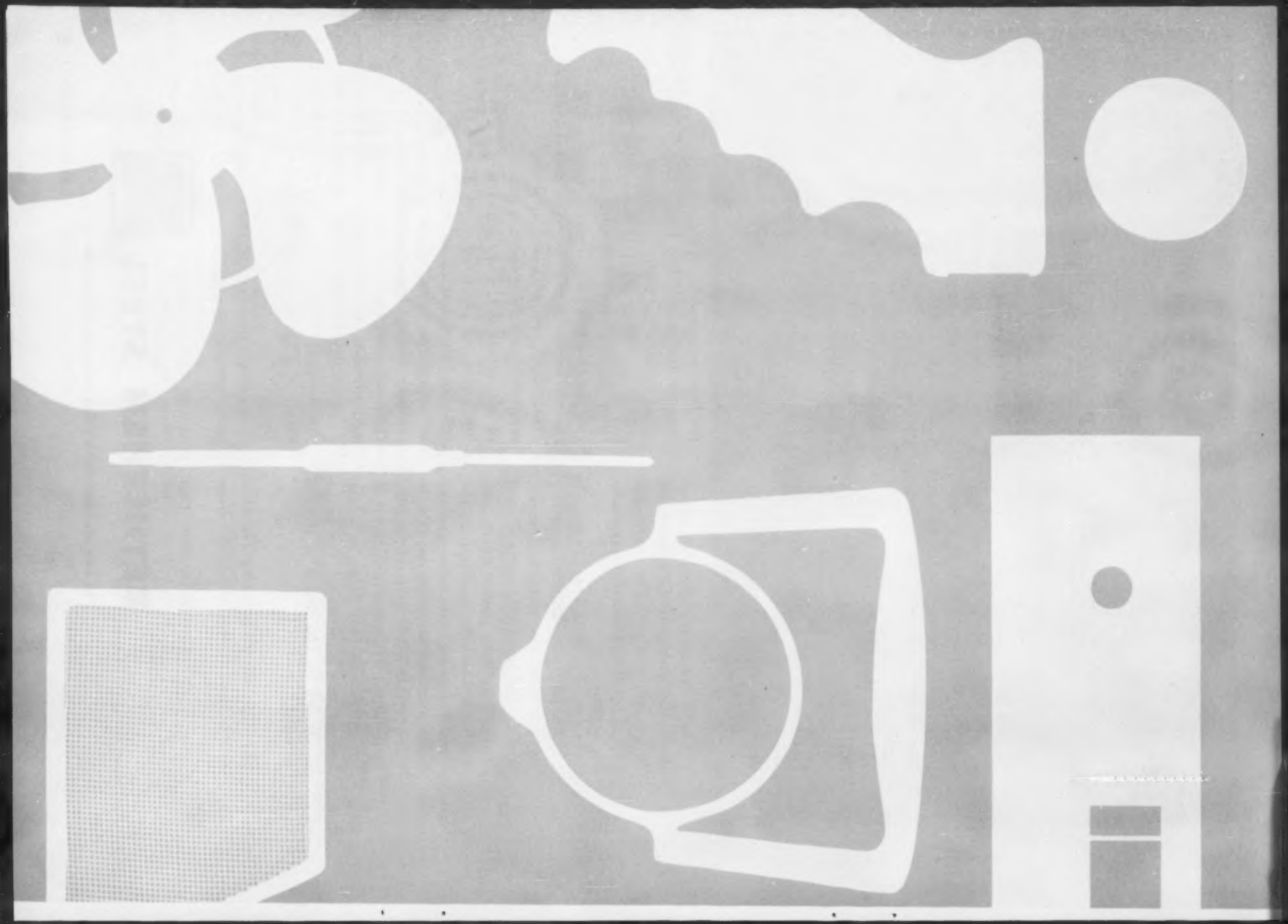
Bethlehem metallurgists will gladly help you with any problem related to quenching or other phases of heat-treatment. They are men of long practical experience in this field, and they understand fully the advantages and limitations of each method. Always feel free to call for their services; their time is yours, without obligation.

Remember Bethlehem, too, when you are next in the market for AISI standard alloy steels, special-analysis steels, or carbon grades. We are always in a position to meet your needs promptly.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
*Export Distributor:* Bethlehem Steel Export Corporation

**BETHLEHEM STEEL**

For more information, turn to Reader Service card, circle No. 426

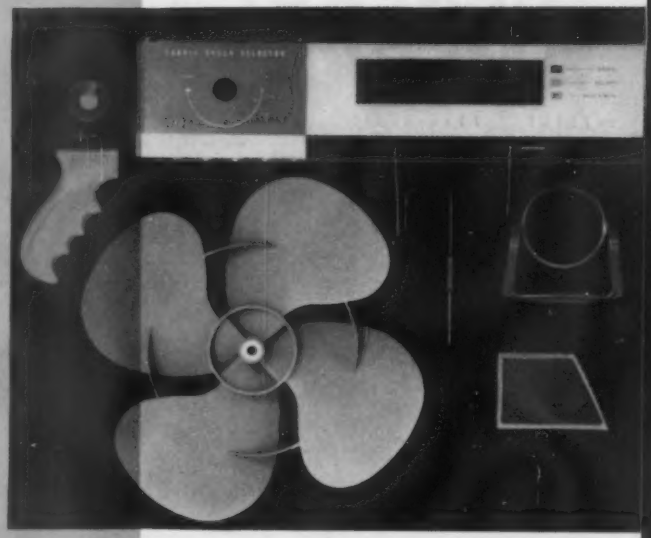


# How the custom molder can help bring your product idea to life

The custom molder is well-known as a mass producer of molded plastics parts and products. But he is much more. Most helpful to the designer, the custom molder knows the design limits of the different plastics. He can recommend the best formulation for the job. He can also engineer the design to capitalize on the inherent advantages of plastics materials and the efficiencies of plastics manufacturing. His toolmakers build the master molds to the closest tolerances. His productive facilities can turn out plastics parts with unusually consistent quality, at rates to meet the tightest schedules and budgets.

Monsanto keeps the custom molder supplied with molding formulations of Monsanto Polyethylene, Lustrex® Styrene, and Opalon® Vinyl, specially developed and constantly perfected to meet a wide range of design requirements.

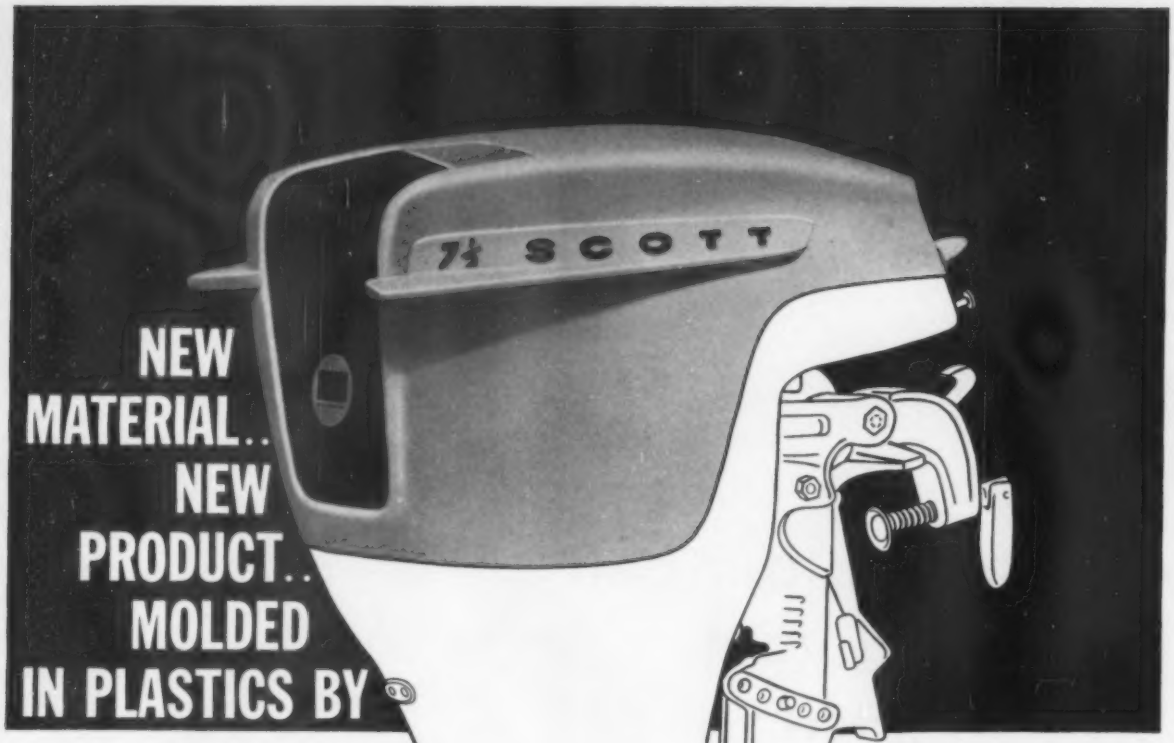
Which molding compounds to consider? Use the Plastics Properties Calculator, an easy-to-read slide rule that provides comparative property data on the many different plastics molding materials. For your free calculator, write to Monsanto Chemical Company, Plastics Division, Room 732, Springfield 2, Mass.



**MONSANTO** PACE-SETTER IN **PLASTICS**

Monsanto

For more information, circle No. 485




# NEW MATERIAL.. NEW PRODUCT.. MOLDED IN PLASTICS BY

# GENERAL AMERICAN

To the raw material manufacturer it was a new plastic with built-in high impact and temperature characteristics, plus high resistance to degrading ultra-violet rays.

To General American, it was a challenge—a problem of finding a suitable user for the plastic and then developing special techniques to mold the material.

The result is the handsome outboard motor hood shown here—the first injection-molded hood ever produced in plastics.

General American, with the nation's foremost molding facilities, investigates every promising new material in order to keep ahead of customer needs. Its engineers and craftsmen are supported by over fifteen years, experience in all fields important to the development of new products in plastics.

You can be sure that if a part or a product can be molded in plastics, General American can mold it for you. You'll find in this field, as in many others, *it pays to plan with General American.*

Plastics Division

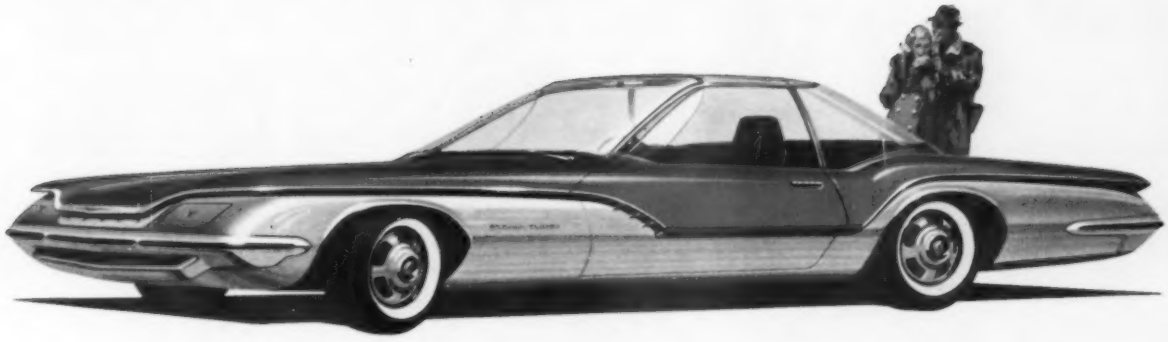
**GENERAL AMERICAN TRANSPORTATION CORPORATION**

*135 South LaSalle Street*
*Chicago 3, Illinois*

PLASTICS DIVISION GENERAL AMERICAN TRADE MARK

For more information, turn to Reader Service card, circle No. 455

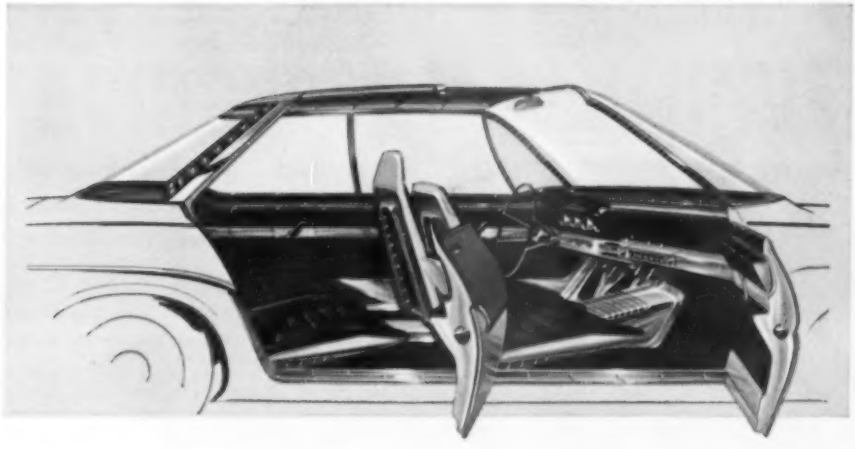
For more information, circle No. 462 ➤



# stainless steel

No other metal has the strength, beauty and versatile qualities that serve you so well today and promise so much for tomorrow.

## There is nothing like stainless steel for AUTOMOBILES



McLouth Steel Corporation,
Detroit 17, Michigan

*Manufacturers of high quality Stainless and Carbon Steels*

Look for the **STEELMARK** on the products you buy.

## McLOUTH STAINLESS STEEL

**1** Vinyl latex gives do-it-yourself paints greater:
*(a) scrub resistance* *(b) one-coat hiding power*
*(c) freedom from lapping and streaking*

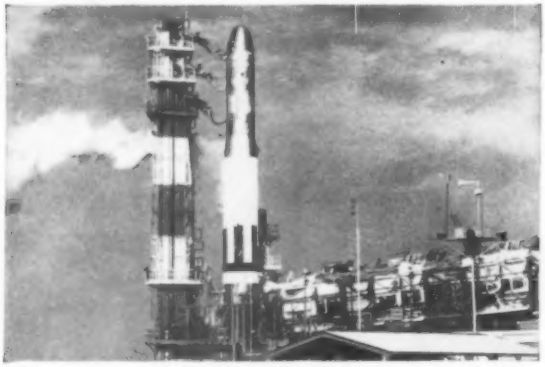
**2** Rich, leather-textured finish on this auto top is:
*(a) baked vinyl coating on steel* *(b) vinyl coating on cloth*
*(c) molded vinyl sheeting*

# Can you pass this test on Vinyl plastics?

*(You'll discover more of their potential as design materials)*

**3** What parts of her shoes are molded vinyl?
*(a) the soles* *(b) the heels*
*(c) the whole shoe*

**4** Well-dressed lambs wear vinyl film to:
*(a) make them easy to find* *(b) keep oil off shepherd's hands*
*(c) protect against rain and cold*



**5** Chief advantage of vinyl jacket for missile control cable is:
*(a) light weight* *(b) flexibility*
*(c) resistance to oxidation*

## ANSWERS... *to a multitude of needs are found in versatile BAKELITE vinyl plastics:*

1. (a), (b), and (c). You're right if you picked them all.
2. (a) Textured vinyl coating on steel looks like leather—wears like iron.
3. (c) The whole shoe—waterproof, tough, glossy and scuff-resistant.
4. (c) Protection against weather—cuts drastic winter lamb mortality.
5. (c) Resistance to oxidizing effect of rocket fuel vapors. Light weight and flexibility contribute to ease of handling.

**If you have questions**— about designing with plastics for function, serviceability, economy and appearance—please ask us. We'll be glad to answer on the practical design and engineering uses of vinyls, epoxies, phenolics, styrenes, and polyethylenes. Just write or call any of our offices or write Dept. DV-01D, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto 7.

UNION CARBIDE

"Bakelite" and "Union Carbide" are registered trade marks of Union Carbide Corporation.

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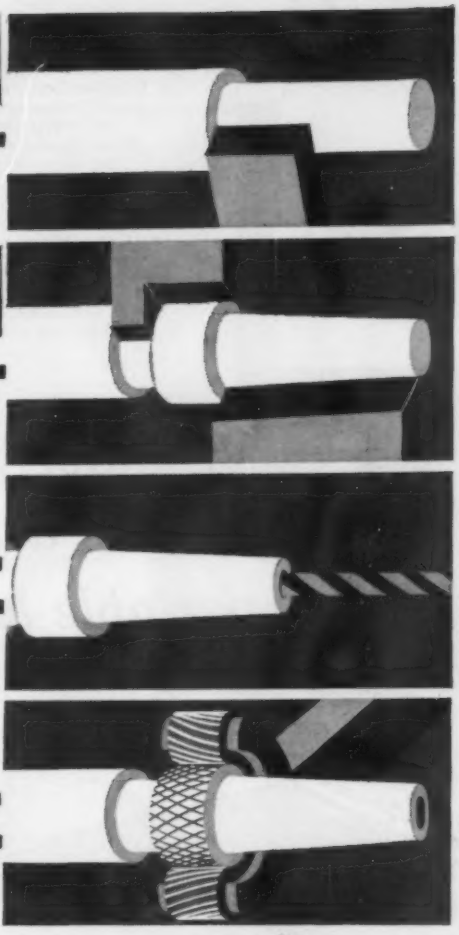
# TURN IT FORM IT DRILL IT KNURL IT



*it still shapes up to savings*

*and the savings are only a phone call away!*

# BRIDGEPORT ALUMINUM

*screw machine rod!*

For machinability you can't top Bridgeport Aluminum Screw Machine Rod. It cuts easily so your parts can be turned out faster; tooling lasts longer, too. And you can count on consistent high quality with Bridgeport because our skill comes from 94 years of experience in the metals industry.

But the big news in Bridgeport Aluminum Screw Machine Rod is its new availability from Bridgeport warehouses across the country. Now you get faster service locally on the same high specification round and hex rod previously delivered from Bridgeport Mills.

So, for fast delivery on Aluminum, Copper and Brass—where and when you need it—call today:

CHICAGO: LAfayette 3-2230
CLEVELAND: CEdar 1-5180
DENVER: AComa 2-4108
ST. LOUIS: CEntral 1-0076
DALLAS: RIverside 1-4859
LOS ANGELES: RAymond 3-5101
NEWARK (Hillside): Bigelow 3-0044
NEW YORK: EXeter 2-4290
PHILADELPHIA: JEfferson 5-3900
PROVIDENCE: WIlliams 1-2100
SAN FRANCISCO: UNderhill 1-2551

Dept. 1504

**BRIDGEPORT BRASS COMPANY**

Bridgeport 2, Conn. • Sales Offices in Principal Cities

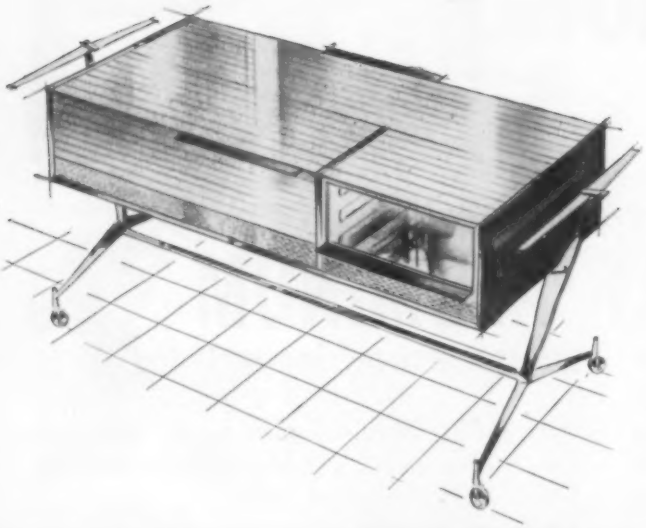
*Specialists in Metals from Aluminum to Zirconium*

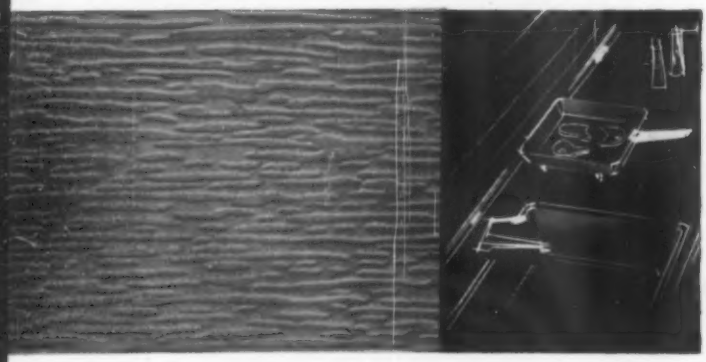
For more information, turn to Reader Service card, circle No. 431

Carl Sundberg and Montgomery Ferar joined fortunes in 1934 and since have had a great influence on improving the design of mass-produced consumer and industrial products.

One of the largest of the nation's recognized design firms, they have put their talents to work on hundreds of nationally known products ranging from pencil clips to heavy-duty motor trucks and electronic computers. Recognized leaders in the design of electrical appliances, they are permanently retained by many of America's best known appliance manufacturers.

# *Sundberg-Ferar designs a unique, portable kitchen caddy with wonderful...*



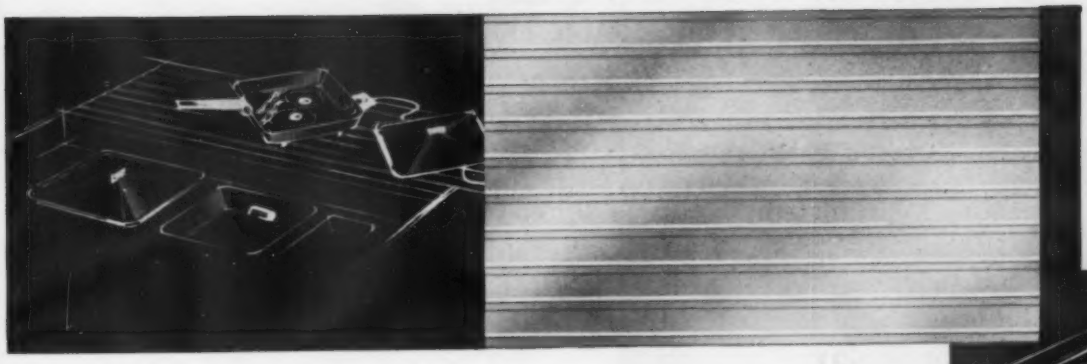


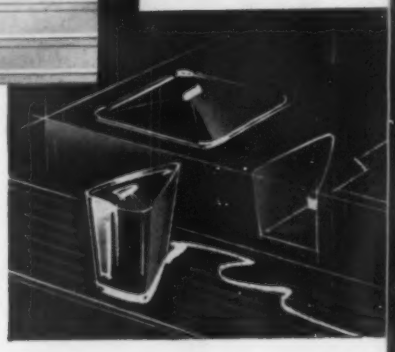
• Sharonart® is truly the designer's metal. Evidence of this fact is this modern kitchen caddy designed in Sharonart® by Sundberg-Ferar, one of the oldest, largest and most successful industrial design firms in the United States.

The portable caddy permits complete cooking facilities anywhere inside or outside of the home. To make sure it would be able to absorb the punishment of daily use, yet stay bright and clean, Sundberg-Ferar designed the cabinet and working areas in patterns of Sharonart® Stainless. Wood grain Sharonart® steel panels at each end give the furniture-look that blends with other home furnishings.

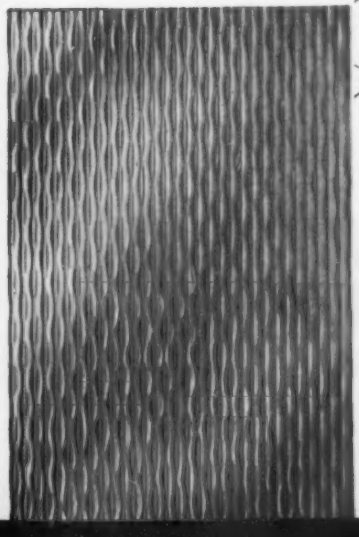
The textured beauty of Sharonart® can be produced in an almost limitless number of patterns. This permits easy model changing. It's easy to clean and will not show wear. It can be painted, plated, or vinyl coated with beautiful results. Is it any wonder that more and more of the leading designers are turning to modern Sharonart® for modern product design? *Sharon Steel Corporation, Sharon, Pa.*

*About the portable kitchen caddy: This is a design only, produced to show the tremendous utility of Sharonart®. All the seemingly built-in utensils are self-energized, and can be plugged into any electrical outlet as well as being used with the caddy itself. The rotisserie has vertical elements that can be moved closer together for the smokeless vertical broiling of steaks. All utensils are removable and can be used at the dinner table for gourmet cooking. Plenty of workspace is provided for complete meal preparation right at the caddy.*





# ...SHARONART®



## SHARON *Quality* STEEL

SHARONSTEEL

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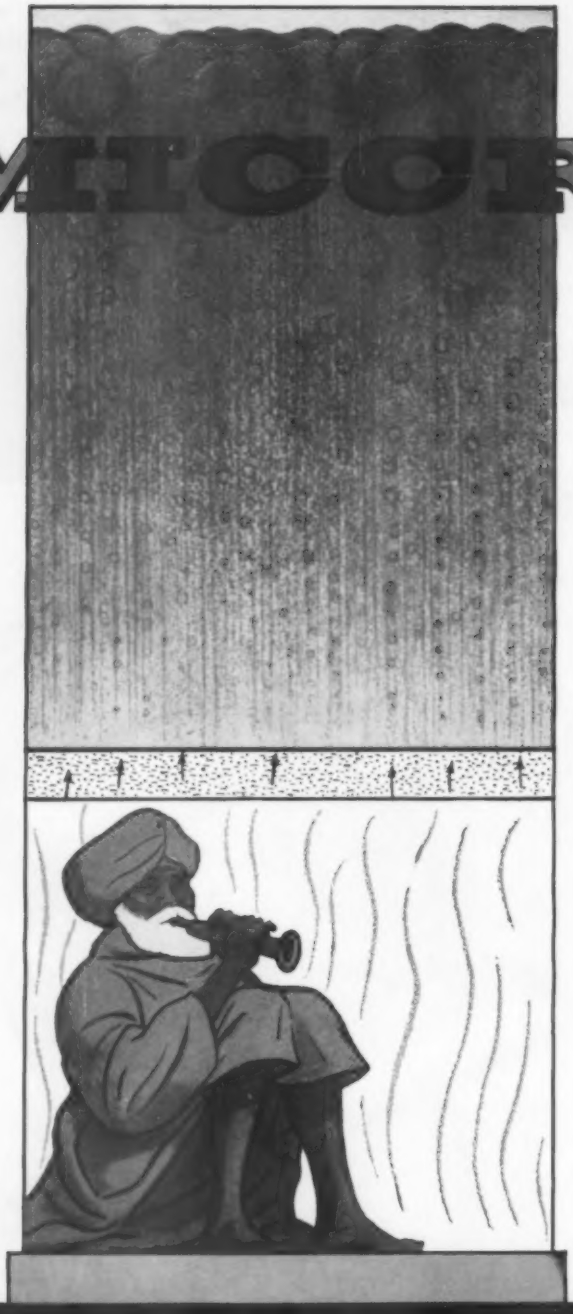
# Our laboratory magic brings you

# MICCRON



## *POWDERED PLASTIC RESINS*

### *for Fusion Coating . . . giving you*

- **New design opportunities**
- **Sales appeal; with exciting, colorful new finishes**
- **Industrial corrosion and/or insulation protection**
- **Drip- and sag-free films**
- **Sharp edge coverage**
- **Wide ranges of materials in: Vinyls, Cellulosics, Epoxies, and Nylons**

Miccron Resins give you the physical and chemical advantages of these plastics in colorful, attractive coatings; applied by flocking, spraying, or the fluidized-bed process.

A six-page brochure, describing Miccron Resins and their application, is yours for the asking. Write us on your company letterhead for the good news on these new, revolutionary coatings.

We'll look forward to hearing from you.

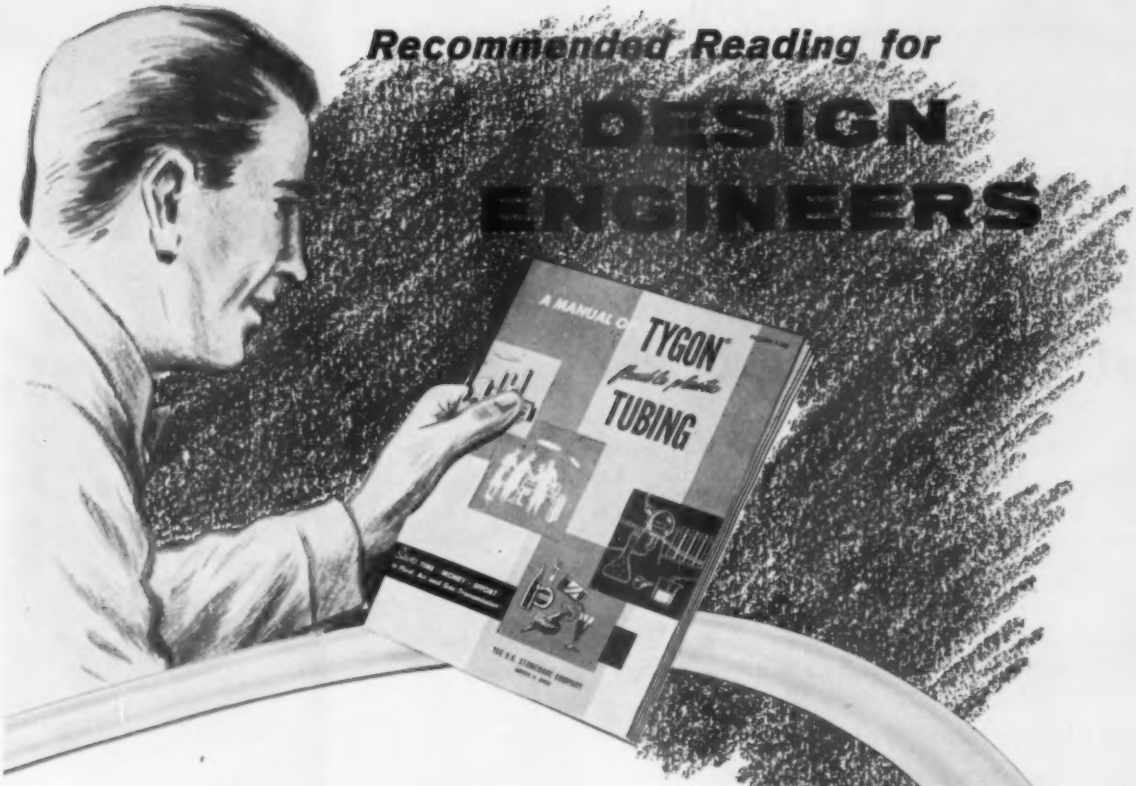
**MICHIGAN CHROME** *and Chemical Company*

8615 Grinnell Avenue, Detroit 13, Michigan

MICCRO Products

For more information, turn to Reader Service card, circle No. 391

## Recommended Reading for DESIGN ENGINEERS




In the pages of this booklet are data every design engineer will want to have when faced with piping problems involving fluids or gases.

Where and how flexible plastic tubing can be used most effectively; how plastic tubings can differ even within a single family of resins; how to select the type and formulation to fit your requirements.

Specifically, of course, it deals with Tygon flexible-plastic Tubing — the flexible plastic tubing most widely used in laboratories, hospitals, food and beverage plants, and in the chemical industries.

Detailed tables outlining the physical, and chemical characteristics of the various standard Tygon formulations, complete table of chemicals to which the tubing is resistant, methods of assembly and cleaning, data on working pressures and temperatures . . . facts which simplify the problems of any engineer . . . are yours in this free booklet.

Write for it today. Ask for Bulletin T-100

TYGON
PLASTIC TUBING

PLASTICS AND SYNTHETICS DIVISION
226E-2

U. S. STONEWARE
AKRON 9, OHIO

For more information, turn to Reader Service card, circle No. 366

**Platinum does it for less.** An important supplier of platinum catalysts for The Pure Oil Company and other refiners is Engelhard Industries, Inc., Newark, N. J., leading suppliers and fabricators of platinum metals, including catalysts...

# Where any metal but Platinum would cost too much...

Why do The Pure Oil Company and other refiners use precious platinum in the processing of high octane gasoline?

The answer is simple economy. Their use of platinum catalyst is the means of getting the quality desired... at low cost.

The fact that the platinum in the "spent" catalyst is recoverable is another important advantage.

The superior activity of platinum metals catalysts has led to the essential roles they play in the processing of vitamins, pharmaceuticals, agricultural and other chemicals.

## It could pay you to use a platinum metal.

Many reactions you are interested in might be more efficiently performed with one of the platinum metals... where peak catalytic efficiency is required as in the refining of high octane gasoline ... where underwater hull protection is a problem ... where a combination of severe corrosion and erosion must be met, as in the case of spinnerettes for rayon production... where wear-resisting, non-tarnishing surfaces are required, such as for printed electrical circuits... or where product purity must be retained despite high temperatures, as in the case of lens glasses... the platinum metals have proved to be the most economical for certain critical equipment.

Industry is going to higher temperatures and higher pressures. Perhaps your own progress has been blocked by the limitations of materials to withstand such severe conditions. The platinum metals have removed many barriers. Have you considered them for your problem?

Platinum, palladium, rhodium, ruthenium and iridium have unique potentials, well worth your attention. Specialists are prepared to work closely with you in evaluating these metals for new commercial and scientific uses.

As a first step, write us for additional data on the outstanding characteristics and successful applications of the six platinum metals and their alloys — indicating your field of interest or how we might be of assistance.

| CAN THESE PROPERTIES OF THE PLATINUM METALS HELP YOU? |
|---|
| Peak Catalytic Activity |
| Exceptional Chemical Inertness |
| Superior Wear Resistance |
| High Temperature Stability |
| Low Vapor Pressure |

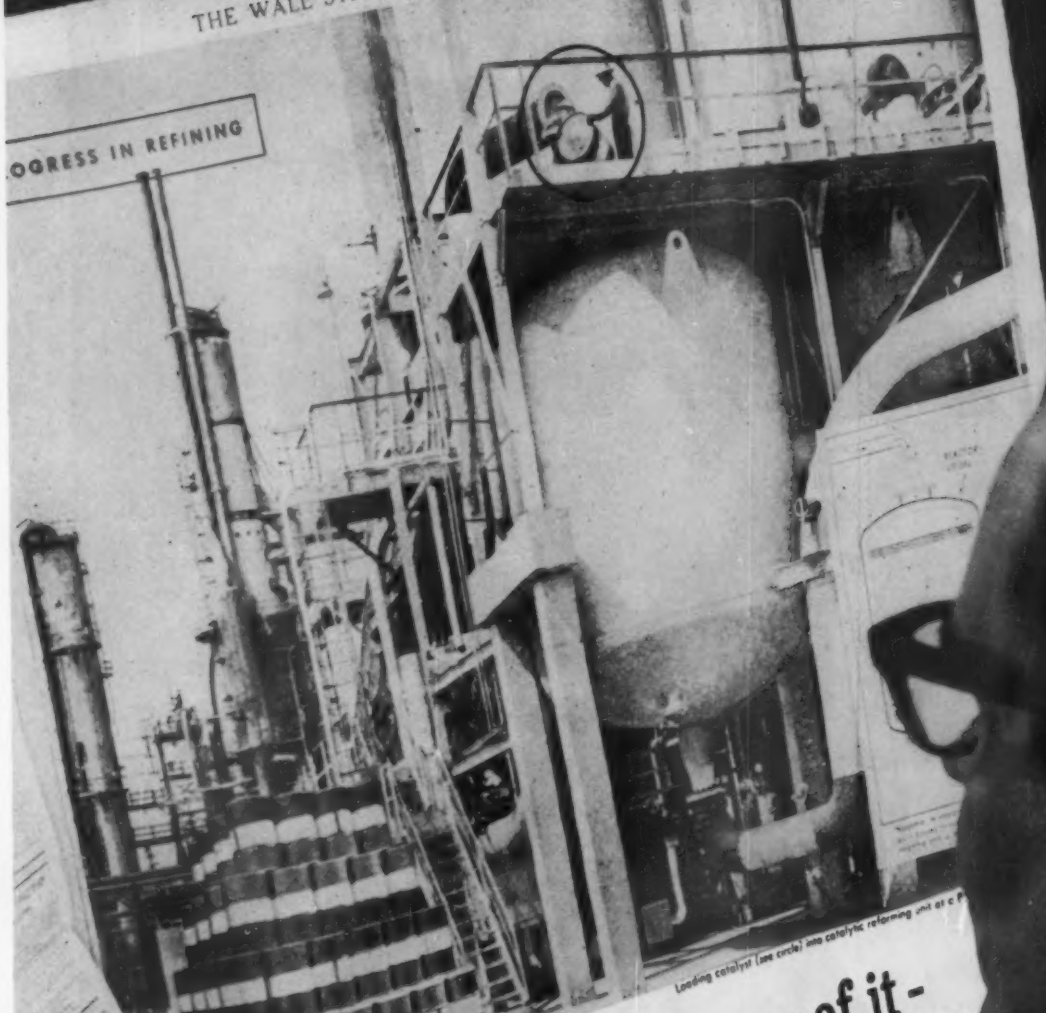
*The six platinum metals are:*
PLATINUM • PALLADIUM • RHODIUM • RUTHENIUM • IRIDIUM • OSMIUM

INCO **PLATINUM METALS DIVISION**
The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

For more information, turn to Reader Service card, circle No. 328

THE WALL STREET JOURNAL.

OGRESS IN REFINING



Loading catalyst (see circle) into catalytic reforming unit at c P

# How platinum - 3/4 of a ton of it - helps put more go in PURE Gaso

**(Another advanced refining process we use—so that you can be sure with PURE)**

To meet the requirements of today's high-compression auto engines, PURE and a number of other oil companies go so far as to use a precious metal—platinum—in their refining operations.

If you saw it, you wouldn't recognize PURE's platinum. We use three-quarters of a ton of it, mixed with tons of other material in the form of small pellets. It's plenty valuable—worth well over $1 million. But it's worth more than that in what it means to Pure Oil customers: better gasoline and improved engine performance.

Platinum is the working ingredient in the catalytic reformers at our refineries. Remaining unchanged itself, the catalyst rearranges and reforms the molecules in naphtha vapor, originally low in quality rating, to make a high-quality blending component for gasoline. PURE has built giant reformers like the one above as part of our program of improving our facilities to meet the never-ending demand for better petroleum products. Another reason why you can be sure—at nearly 16,000 Pure Oil dealers in 24 states.

THE PURE OIL COMPANY, 35 E. Wacker Dr., Chicago 1

PURE

# "SHELVED" PROJECTS NOW POSSIBLE

## Super Alloys key to advanced development work

Marked improvement in elevated temperature properties of new superstrength alloys is permitting design engineers to move ahead on projects once considered impractical. This is perhaps most evident in the aircraft, missile, jet and turbine power fields. It is, by no means, limited to these alone.

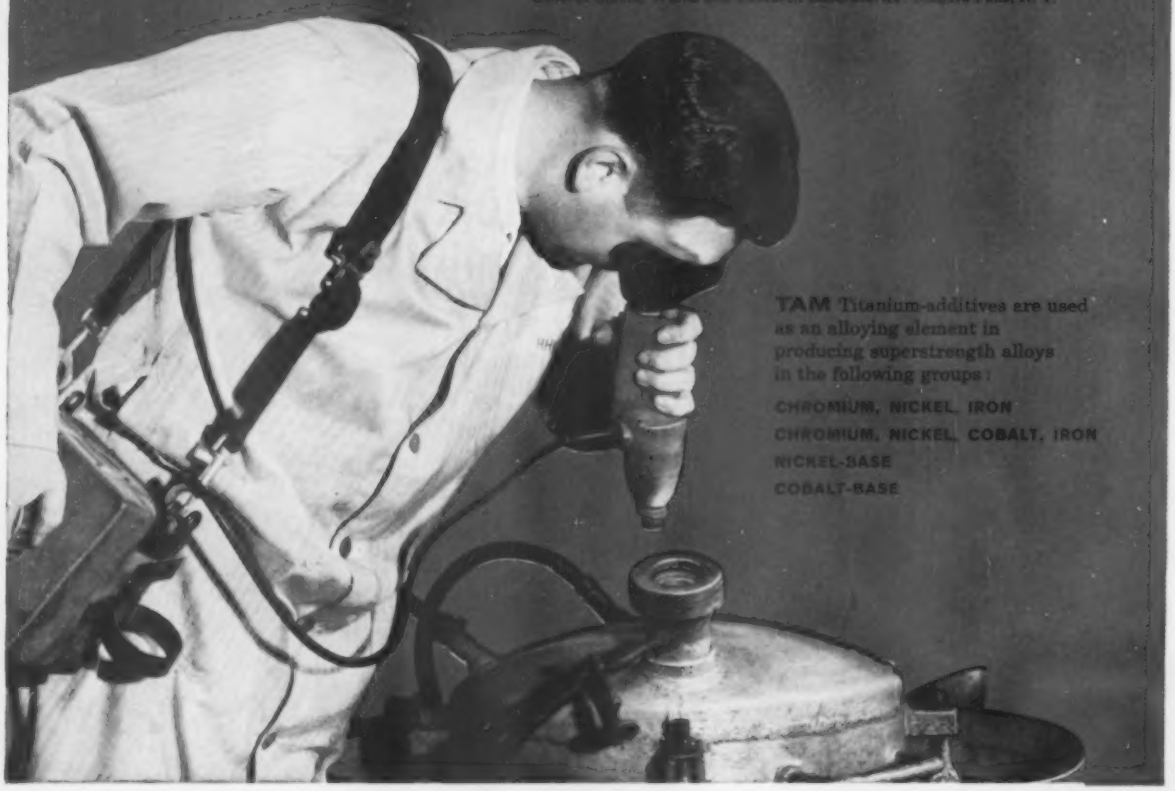
Using advanced techniques and processes, metallurgists are producing a variety of new and improved alloys with superior physical properties.

Where strength at elevated temperatures is the major factor, alloys containing Titanium as the alloying element offer many practical advantages. We suggest that investigation of these titanium-bearing alloys now may lead to the design and production of end products with many new application possibilities. A letter to our N Y C office can be a logical first step to getting certain projects off the shelf and into being.

**TAM**

DIVISION NATIONAL LEAD COMPANY

*Executive Offices*, 111 Broadway, New York City
*General Offices, Works and Research Laboratories*: Niagara Falls, N. Y.



**TAM** Titanium-additives are used as an alloying element in producing superstrength alloys in the following groups:

CHROMIUM, NICKEL, IRON
CHROMIUM, NICKEL, COBALT, IRON
NICKEL-BASE
COBALT-BASE

For more information, turn to Reader Service card, circle No. 408

# PRODUCT-DESIGN BRIEFS FROM DUREZ

- What a solvent cement can do
- Something new in electrical insulation
- A bulletin on plastics

### Stuck?

A good adhesive does a lot more than stick two things together. You can use

today's solvent-type adhesives to:

- smooth out surface contours (as in brake linings and in jet aircraft skins, where adhesives can eliminate the need for projecting rivets);
- distribute stress uniformly over a surface, rather than concentrating it at welded or riveted points;
- build up large structural members from many small components;
- reduce galvanic action between dissimilar metals, and so lessen the risk of corrosion.

One super-sticker in this class sets with only contact pressure and at room temperature; adheres very well to metal, wood, phenolic laminates, glass, and rubber. Block shear tests show 4500 psi at room temperature, and tensile strength is 10,000 psi. The cement has excellent resistance to all ordinary solvents, water, oils, alkalies, and acids; has high capillary attraction and does not shrink.

**We don't make adhesives.** We do make heat-setting phenolic resins that give many of the newer adhesives more gripping power and more *permanence*. Next time you have a fastening problem, give these new solvent-type adhesives a chance to show you what they can do.

### Stock insulation shapes

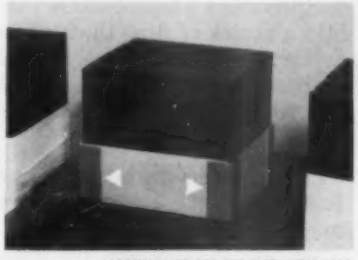
This insulation idea solves three engineering problems at once in a dry-type transformer. You'd find the same approach helpful in a circuit breaker, a panel, or other heavy-duty electrical gear.

See the plastic angle pieces (below)? They insulate the corners of the laminated steel core from the windings, at the high-stress areas. They take the place of roll-formed fiber. Advantages:

1. Greater mechanical strength. This ends cracking or breaking of insulation when windings are forced into position.
2. Better resistance to moisture. The insulation doesn't swell or shrink, maintains its dielectric strength under the clammiest conditions.
3. Higher heat resistance. The angle is made with glass-reinforced Hetron,® our inherently heat-resistant polyester resin. It meets NEMA GPO-1 specifications, and has UL-recognized flame retardance. It is designed for equipment operating at Class B temperatures (266°F.).

Now for the clincher. You can get flame-retardant structural insulation like this *from stock*—in a wide range of cross-section shapes including channels, in widths up to 9 21/32 inches, lengths to 76 inches.

You get them not from us but from the manufacturer, The Glastic Corporation, 4321 Glenridge Road, Cleveland 21, Ohio. The Glastic people will be glad to send you details on stock channels and angles if you write to them.



PRECISION WELDER AND FLEXOPRESS CORP.

### Facts without a file

What does a man do when he wants to know more about Durez plastics?

He looks in Sweet's File. There he finds eight pages packed with the what, how, when, where, and why of using Durez materials—phenolic and diallyl phthalate molding compounds, Hetron polyester resins, phenolic resins.

What if he hasn't got Sweet's File handy? He sends us the coupon below, requesting Durez *Bulletin D400*. The same fact-filled eight pages come to him posthaste.

**For more information** on Durez materials mentioned above, check here:

- ☐ Phenolic resins (12-page bulletin listing applications)
- ☐ Hetron fire-retardant polyester resins (data file, including names of fabricators)
- ☐ Durez plastics *(Bulletin D400)*

**Clip and mail** to us with your name, title, company address. *(When requesting samples, please use business letterhead)*

**DUREZ** PLASTICS DIVISION

1404 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

For more information, turn to Reader Service card, circle No. 326

## thanks to FRASSE tubing!

Seamless Mechanical Tubing
Welded Mechanical Tubing
Pressure & Hydraulic Tubes
Centrifugally Spun Tubing
Stainless Seamless Tubing
Stainless Welded Tubing
Stainless Pipe, Valves & Fittings
Aluminum Tubing, Pipe & Fittings

Call FRASSE 1st for tubing

Spectators gasped when this sprint car skidded—at 95 m.p.h.—into a series of flips that seemed certain to demolish both car and driver. Yet—miraculously, the driver walked away from the wreck with only minor bruises. His roll bar—made from Frasse tubing—had shielded him by taking the full impact of the car...not once, but *four times.*

The capacity to take such abuse is inherent in seamless tubing. It combines the ability to absorb and localize shock, with the ultimate in strength and rigidity in proportion to size and weight. Then too, it possesses superior welding and machining properties. That's why more and more engineers specify seamless tubing... for structural and mechanical applications.

Every tube in Frasse stocks meets the rigid quality specifications set by Frasse tubing specialists. So, if you use tubing in your product —and want trouble-free quality in a hurry...*it will pay to make Frasse your source for tubing.* There's a size on hand to meet every need...delivery is immediate...and Frasse engineers are available to assist you with any problem involving a tubular product.

Peter A. Frasse & Co., Inc.

AMERICAN STEEL WAREHOUSE ASS'N
YOUR STEEL SERVICE CENTER

| NEW YORK 13, N. Y. | PHILADELPHIA 29, PA. | BUFFALO 7, N. Y. | SYRACUSE 1, N. Y. | HARTFORD 1, CONN. |
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For more information, turn to Reader Service card, circle No. 380

# A first by AllianceWall

*porcelain enameled sheets for practical application to vanities and cabinets*

Now!! With AllianceWall in its three easy-to-use forms you too can design porcelain enamel surfaces into your products with greater production freedom than ever before.

Available in coils up to several hundred feet in length . . . laminated sheets in sizes up to 4′ x 12′ . . . or in panels laminated to the material of your choice, (cut in sizes to your specifications, if necessary) AllianceWall lets you saw, trim or drill with ordinary production tools *right* on your production line. Select from 28 standard glass-hard, non-fade colors or special colors on request. Let us help you design AllianceWall to your product.

*Porcelain enamel AllianceWall gives color fast beauty and lifetime mar-free surface to this beautiful vanity designed by Peter Muller-Munk Associates*

# AllianceWall

AllianceWall Division, AllianceWare, Inc.
Box 809, Alliance, Ohio

an amp subsidiary

For more information, turn to Reader Service card, circle No. 492

# ENJAY DELIVERS 1,000,000th LONG TON OF BUTYL!

## PRODUCTION FACILITIES INCREASED TO MEET CONSTANTLY GROWING DEMAND

There have been many elastomers developed since the first commercial ton of Butyl was used in 1943, but no other rubber, synthetic or natural, offers so many outstanding properties for so many applications.

Plant expansion plans announced recently will increase butyl production capacity some 50 percent by 1961 and, at today's rate of consumption, the two million-ton mark will be reached within the next six or seven years. Two new additions to the butyl product line, Chlorobutyl and Butyl Latex, will soon be available in commercial quantities.

VERSATILE ENJAY BUTYL'S OUTSTANDING PROPERTIES MAKE IT SUPERIOR TO OTHER RUBBERS FOR MANY APPLICATIONS. SOME ADVANTAGES:

- **RESISTS TEAR AND ABRASION** ... used in the new and revolutionary all-butyl tire.
- **STANDS UP AT HIGH TEMPERATURE** ... used in steam hose and tire curing bladders
- **HAS EXCELLENT ELECTRICAL PROPERTIES** ... used in high voltage cable insulation
- **IS IMPERMEABLE TO GASES** ... used in virtually all rubber air-holding applications
- **HAS WIDE RANGE OF DYNAMIC PROPERTIES** ... used in over 100 applications on the modern automobile
- **DISPLAYS OUTSTANDING CHEMICAL RESISTANCE** ... used for the storage and shipment of many chemical and commodity products
- **WITHSTANDS EXPOSURE TO SUN AND WEATHER** ... used in irrigation pipe and roof coatings.

*Want to find out fast, how versatile Butyl can improve your product? Call or write the nearest Enjay office.*

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

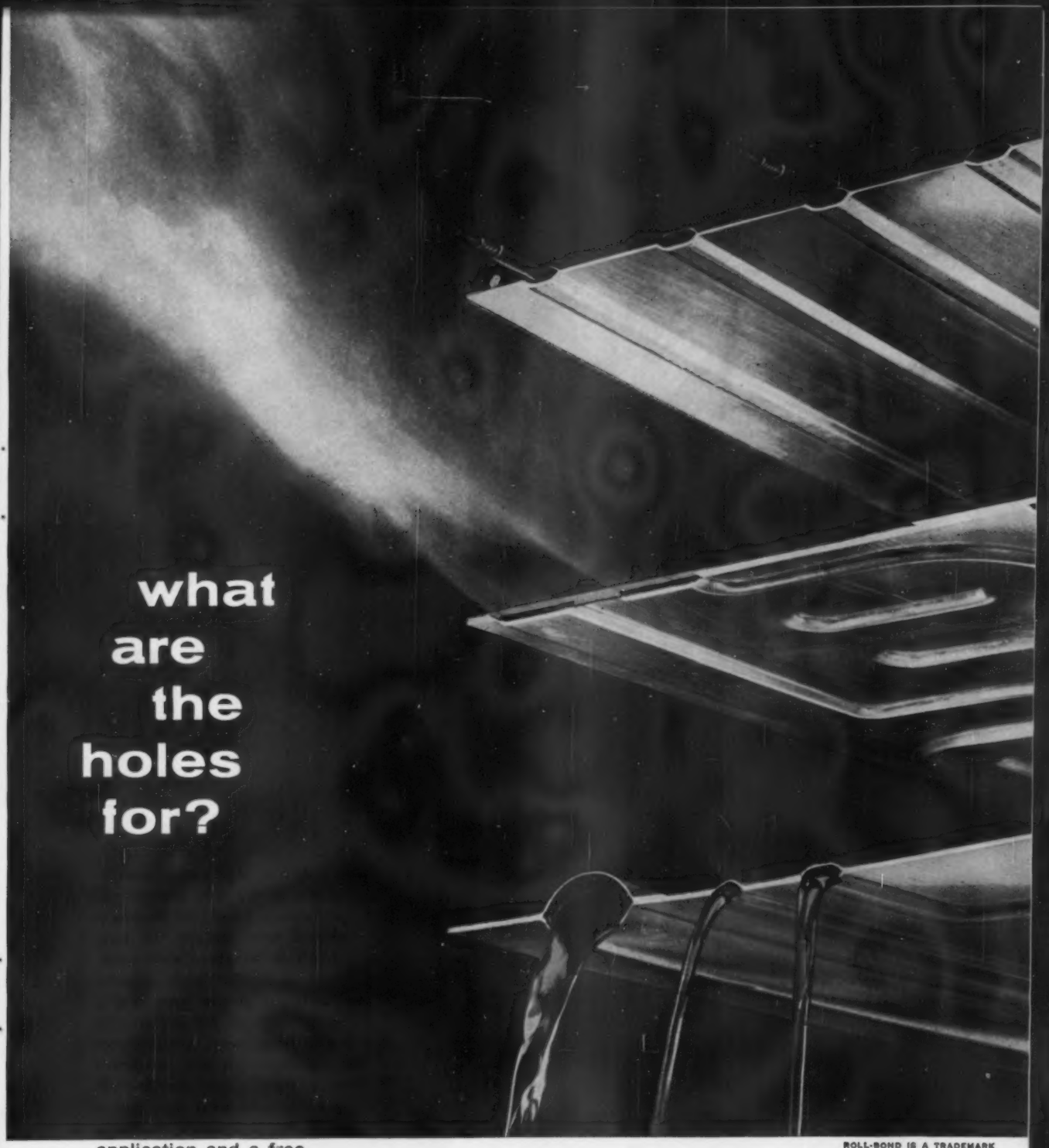
ENJAY COMPANY, INC.

*15 West 51st Street, New York 19, N.Y.*

*Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa • Toronto*

ENJAY® BUTYL

For more information, turn to Reader Service card, circle No. 435




application and a free illustrated booklet explaining Roll-Bond in more detail. Contact Olin Mathieson today: Metals Division, Roll-Bond Products, East Alton, Ill.

ROLL-BOND IS A TRADEMARK

ROLL-BOND PRODUCTS

"inflated" aluminum sheet

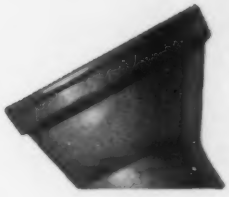
OLIN MATHIESON • METALS DIVISION

Producers of: Roll-Bond, Western Brass and Olin Aluminum

For more information, turn to Reader Service card, circle No. 416

# FOR THE MACHINERY PART

# THAT TAKES THE BEATING



Perfect performance for 100,000 hours at orange heat, in the combustion chambers of diesel engines, is quite an achievement. Yet it's the record of tens of thousands of special combustion cups of HASTELLOY alloy C in a well-known line of diesels.

The alloy was chosen for its unique high-temperature strength and corrosion resistance and its outstanding ability to hold heat.

These and other special properties are built into HAYNES alloys —to fit the particular needs of design and production engineers for machinery parts that must meet the roughest service conditions.

If you are designing such a part, investigate HAYNES alloys. There are more than 15 to choose from. They include HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

## HAYNES Alloys *will do the job!*

**HAYNES ALLOYS**

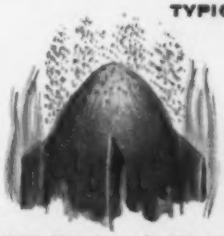
**HAYNES STELLITE COMPANY**
*Division of Union Carbide Corporation*
Kokomo, Indiana

UNION CARBIDE

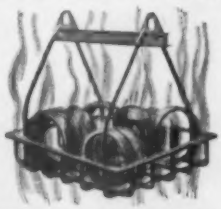
**Address inquiries to Haynes Stellite Company, 420 Lexington Avenue, New York 17, N. Y.**

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

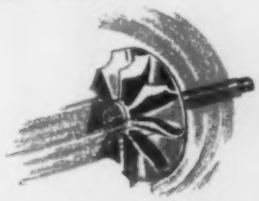
**TYPICAL "HAYNES" ALLOY PARTS THAT RESIST...**



**ABRASION.** Ten times the life and still no sign of wear, is the record of this plastics-extrusion torpedo nose made of HAYNES STELLITE alloy No. 3. This is one of many HAYNES wear-resistant alloys.



**CORROSION.** Baskets made of HASTELLOY alloy C used for holding forgings during acid treatment, are still good after 15 months of service. Materials formerly used were replaced every month.



**HIGH TEMPERATURE.** Turbine wheels in the "hot" ends of diesel engine turbochargers are investment-cast of HAYNES STELLITE alloy No. 31, for service at speeds up to 50,000 rpm. at 1500 deg. F.

For more information, turn to Reader Service card, circle No. 480

# Coro-Gard® 1706 withstands

**BRAND PROTECTIVE COATING**

**METAL** coated with Coro-Gard 1706, right side, shows no effect from salt spray attack. Corroded left side is untreated.

# 2000-hour corrosion attack

Real corrosion resistance!—That's what you get when you specify new CORO-GARD 1706 Brand Protective Coating.

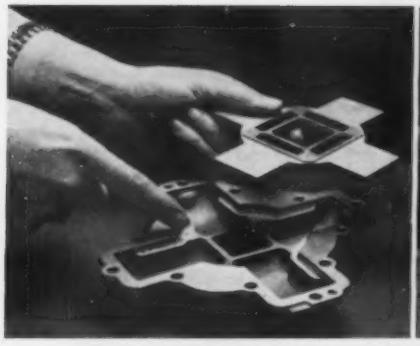
Specify CORO-GARD 1706 Coating for steel, aluminum, wood, concrete, cloth, even some plastics—wherever corrosion or abrasion must be fought. It provides maximum protection at low cost, brushes on as easily as paint. Self-priming, it goes on vertical surfaces with minimum sagging, provides unusually high coverage for economical use.

This neoprene rubber based coating air-cures to a tough, rubbery, protective film with exceptional resistance to corrosive fluids and fumes, water and abrasion. It successfully resisted a 2000-hour salt spray attack, a 20-week submersion in 20% solution of hydrochloric acid, and a six-month weather exposure in Miami, Florida. After all this, CORO-GARD 1706 Coating still maintained its exceptional adhesion and flexibility, its corrosion and abrasion resistance.

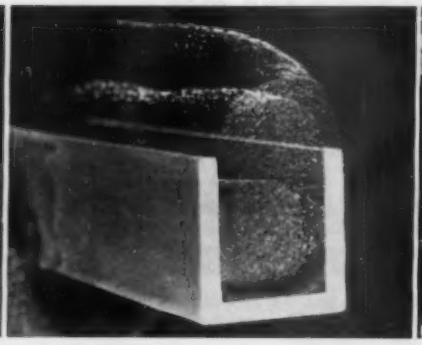
See how CORO-GARD 1706 Coating can help you. For complete information, write today on your company letterhead, specifying area of interest, to: AC&S Division, 3M, Dept. SBHH-40, St. Paul 6, Minn.

"CORO-GARD" is a Reg. T.M. of 3M Co.

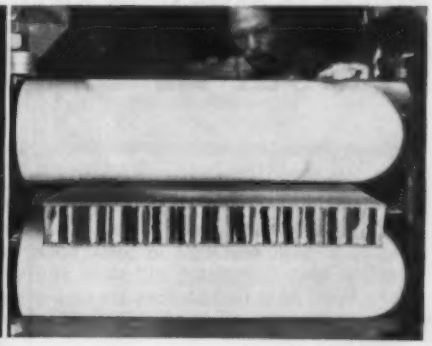
## News about other 3M products



**SIMPLIFIED PRODUCTION.** 3M Adhesive EC-1386 bonds sections of hollow castings. This simplified method of producing complex castings eliminates high rejection rate of sand molding, costly machining, equipment required for mechanical fastening. The adhesive bond fills voids, cures quickly, can be machined for final touch-up.



**SURE WAY TO SEAL.** 3M Heat Expandable Sealers expand up to 125% under the normal heat of a paint-baking cycle, cure to a tough, flexible mass that keeps out dirt, water and weather, completely seal even the most irregular gap or seam. The unexpanded solid is also efficient as a gasket replacement sealer, flange sealer, and for other sealing jobs.



**COLD SANDWICH BONDING.** 3M Adhesive EC-1357 makes it possible to bond sandwich panels with a nip roller or cold press. You need no clamps or heated presses to complete tough core-to-skin bonds that resist moisture and high and low temperatures. This one adhesive bonds a variety of materials quickly, economically. Because of its dark color, it absorbs infrared heat quickly, dries fast.

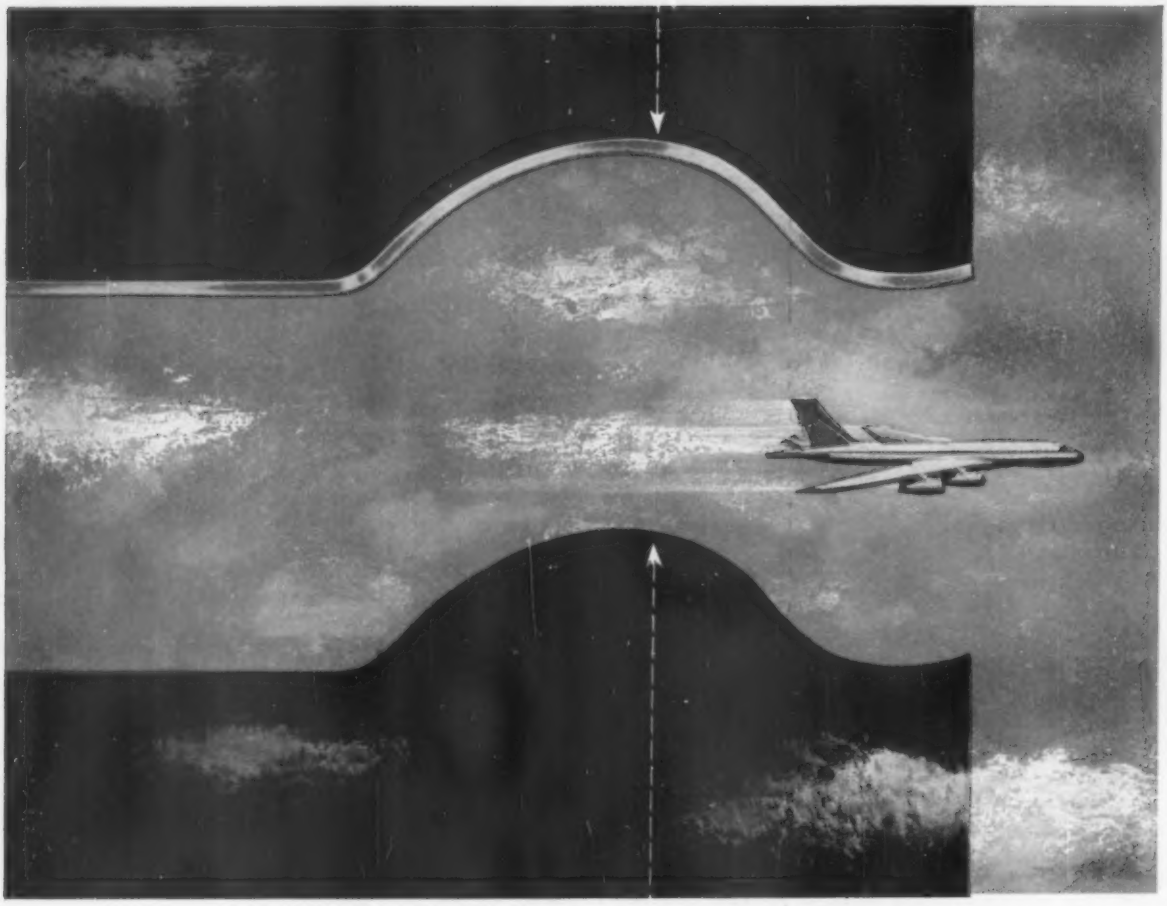
ADHESIVES, COATINGS AND SEALERS DIVISION

**MINNESOTA MINING AND MANUFACTURING COMPANY**

**. . . WHERE RESEARCH IS THE KEY TO TOMORROW**

3M COMPANY

For more information, turn to Reader Service card, circle No. 330



## Want to save with plastic tools and dies?

# Your EPON® RESIN tooling formulator can help you

Tools and dies made of tough but easy-to-handle Epon resin can save you up to two thirds in time, one third in cost! Your tooling resin formulator will show you how Epon resin formulations are saving time and money—*right now*—in applications such as:

**High-temperature tooling:** Metal-forming stretch dies that can operate at temperatures over 400° F.

**Heated tools:** Matched dies, with integral heating units, may be made with Epon resin formulations for rapid heat-curing of laminated plastic parts.

**Long-lasting metal-forming tools:** Castings made of formulated Epon resin, mounted in a crank press, showed no permanent deformation after 28,000 compression-shock cycles.

For tool and die applications, Epon resin formulations offer you the following important advantages:

**Excellent tolerance control:** Little machining and handwork are required to finish Epon resin tools because of the material's excellent dimensional stability and lack of shrinkage.

**Outstanding strength:** Jigs and fixtures with thin cross sections can be built from Epon resin-based formulations reinforced with glass cloth. The resulting laminate has high flexural strength and excellent dimensional stability.

**Easy modification:** Tools and fixtures made from Epon resins may be quickly and easily modified to incorporate design changes.

### CONTACT YOUR TOOLING RESIN FORMULATOR

The combination of resin formulator's skill and application knowledge, backed by Shell Chemical's research and resin experience, has solved many important tooling problems for industry. For a list of experienced tooling resin formulators and additional technical information, write to:

**SHELL CHEMICAL COMPANY**
**PLASTICS AND RESINS DIVISION**
110 WEST 51ST STREET, NEW YORK 20, NEW YORK

| Central District | East Central District | Eastern District | Western District |
|---|---|---|---|
| 6054 West Touhy Avenue | 1578 Union Commerce Bldg. | 42-76 Main Street | 10642 Downey Avenue |
| Chicago 48, Illinois | Cleveland 14, Ohio | Flushing 55, New York | Downey, California |

IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited, Toronto

SHELL

**For more information, turn to Reader Service card, circle No. 448**

Setko's 23 Years of Progressive Engineering Experience Keeps Screws Modern as Tomorrow's Products

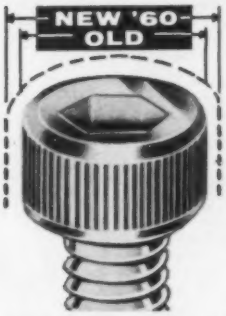
# SETKO NEWS

Bartlett, Illinois (Chicago Suburb) Progress Edition

We Specialize in Solving Puzzling Screw Problems

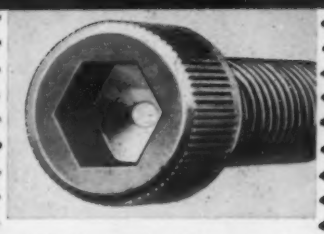
# NEW '60* SERIES CAP SCREWS HAVE EXTRA HOLDING POWER

## 4 BIG EXTRA MONEY-SAVING ADVANTAGES WITH SETKO




Compare the new head sizes of the new '60 series with the old '36 series and you'll *see* the many *extra* money saving advantages you get. For example: *Broader bearing area under the head*—often eliminates the need for washers. *Bigger head sockets for greater tightening torque*—give more holding power.

*You get this extra size only where it counts*—in the extra width of the head. (Head height remains unchanged.) In addition, you get *longer service life* and *more re-use value* when you specify Setko '60 series, Cold-Forged, Socket Head, Cap Screws.



*A Setko exclusive*

### "PERFECT-HOLE" SOCKETS

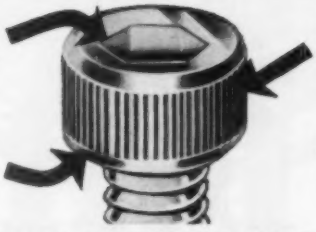
**assure perfect key engagement!**

You can exert maximum torque for *total* holding power because the hex socket is perfect. Permits perfect engagement of hex key against all of the bearing walls of the socket. Pressures exerted on the socket, are perfectly equalized for maximum driving power. Cap Screw life is extended and more re-applications are possible. Specially designed machinery and die tools, built to Setko specifications, are the reason for these cost-cutting, life-lengthening, money-saving, *plus* features.

## LARGER HEAD SIZE PAYS OFF IN SAVINGS

**BIGGER HEAD SOCKETS** on many sizes take greater tightening torque without breakage or damage.

**BROADER BEARING AREA** under the head, distributes the load over a larger bearing area. Stops needless indenting of softer metals.



**BETTER STRENGTH CHARACTERISTICS** assure longer life—can be reapplied more times.

**STAINLESS STEEL** Cold-forged Cap Screws now available in many sizes.

## DATA CHART SHOWS INCREASED SIZES

*'36 series will continue to be available.

| Screw Size | Min. Head Dia. Inches | | Bearng Area Min. Sq. In. | | % Increase Bearing Area | Hex Key Size (Width Across Flats) | |
|---|---|---|---|---|---|---|---|
| | 1936 | 1960 | 1936 | 1960 | 1960 over 1936 | 1936 | 1960 |
| # 2 | .136 | .134 | .006 | .006 | — | 1/16 | 5/64 |
| # 3 | .157 | .154 | .008 | .008 | — | 5/64 | 5/64 |
| # 4 | .178 | .176 | .011 | .011 | — | 5/64 | 3/32 |
| # 5 | .200 | .198 | .015 | .015 | — | 3/32 | 3/32 |
| # 6 | .221 | .218 | .019 | .019 | — | 3/32 | 7/64 |
| # 8 | .265 | .262 | .026 | .026 | — | 1/8 | 9/64 |
| #10 | .306 | .303 | .036 | .036 | — | 5/32 | 5/32 |
| 1/4 | .367 | .365 | .044 | .044 | — | 3/16 | 3/16 |
| 5/16 | .429 | .457 | .052 | .070 | 33 | 7/32 | 1/4 |
| 3/8 | .553 | .550 | .111 | .111 | — | 5/16 | 5/16 |
| 7/16 | .615 | .642 | .147 | .200 | 36 | 5/16 | 3/8 |
| 1/2 | .739 | .735 | .183 | .183 | — | 3/8 | 3/8 |
| 5/8 | .863 | .921 | .216 | .293 | 35 | 1/2 | 1/2 |
| 3/4 | .987 | 1.107 | .224 | .424 | 89 | 9/16 | 5/8 |
| 7/8 | 1.111 | 1.293 | .253 | .585 | 131 | 5/8 | 3/4 |
| 1 | 1.297 | 1.479 | .405 | .768 | 89 | 5/8 | 3/4 |

For dimensions on 36 series see latest Setko Catalog.

*Ask for free test samples*

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Contains complete specifications, dimensions and information about the new Setko '60 series of Cold-Forged, Socket-Head, Cap Screws. Fill in the coupon below, tear out and mail today. Ask for free test samples. Send us your requirements for advantageous quotations.

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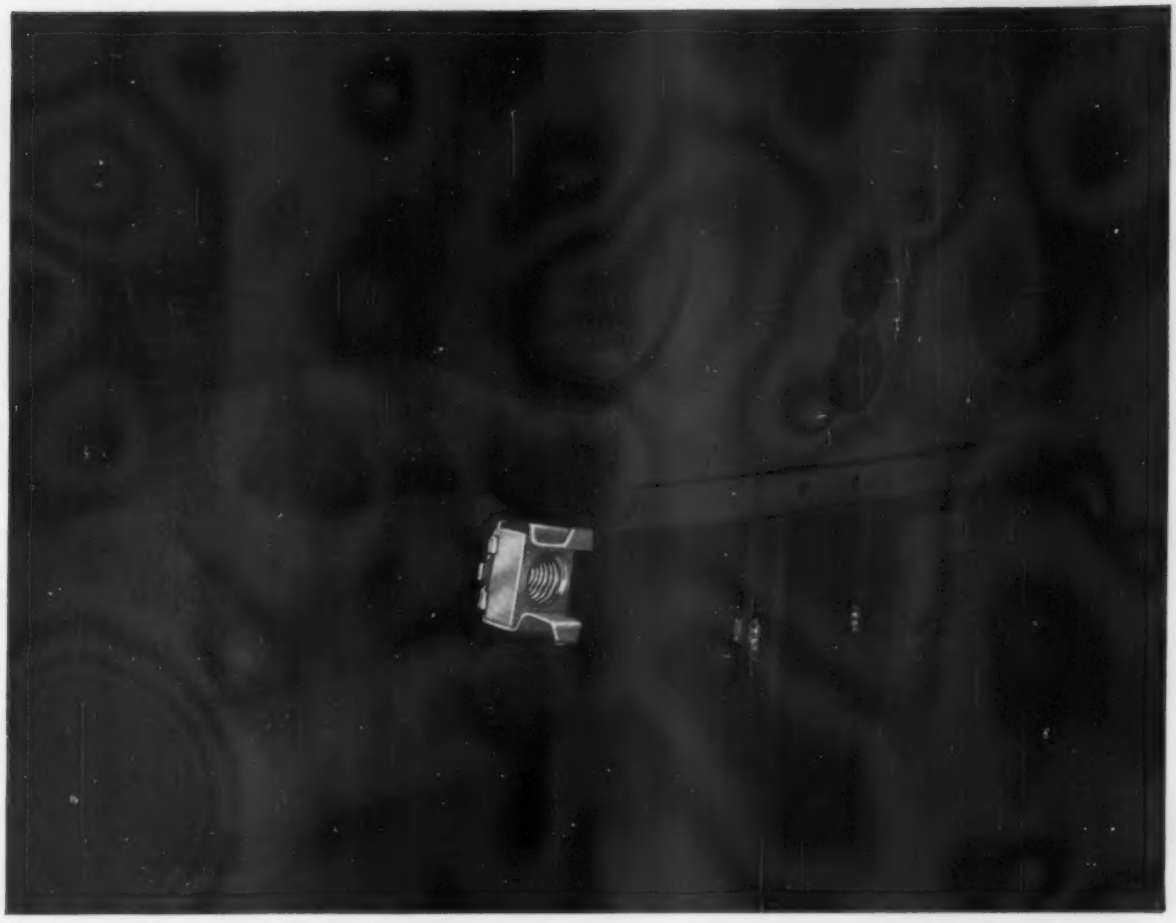

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# Easier, faster, better, cheaper...4 reasons to use **SPEED GRIP**® Nut Retainers

***Easier*** ... because anyone anywhere on the J. I. Case tractor production line can snap the spring steel retaining legs of the SPEED GRIP into punched panel holes. No special skill required. Hole alignment is no problem – the nut "floats" inside the cage to compensate for normal tolerances in the parts being assembled.

***Faster*** ... no staking, no welding. No retapping of paint-clogged threads because SPEED GRIPS can be applied *after* painting. And they pop quickly and easily into position for final assembly.

***Better*** ... heavy-duty SPEED GRIPS make possible sturdy, reliable attachments because both the cage and the nut are made of high quality steel. In case of accidental cross-threading, the SPEED GRIP can easily be replaced. You never have to "make do" with a sub-strength fastening.

***Cheaper*** ... J. I. Case estimates a savings of about 30% per fastener over the previous method.

Want to achieve these benefits of SPEED NUT Brand Fasteners for your product? Refer to your Sweet's Product Design File, section 7-Ti, then call your Tinnerman representative (listed in most Yellow Pages under "Fasteners"). Or write to:

**TINNERMAN PRODUCTS, INC.**
**Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio**

**TINNERMAN**
*Speed Nuts*®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

For more information, turn to Reader Service card, circle No. 394

HERCULES

Plastics Hi-Lites

Vol. II, No. 1

# New plastics are the big story in today's modern appliances

**INSIDE OR OUT, PRO-FAX® APPLIES**—a real performer, Pro-fax! It's built to stand up to the most rugged use challenges whether they be indoors or outside. As a result, this newest of plastics—Hercules polypropylene—has been finding increasing use in appliances that call for the finest in appearance and performance. Tough, rigid, heat-resistant, hard to stain, Pro-fax is richly colorful and the lightest plastic ever.

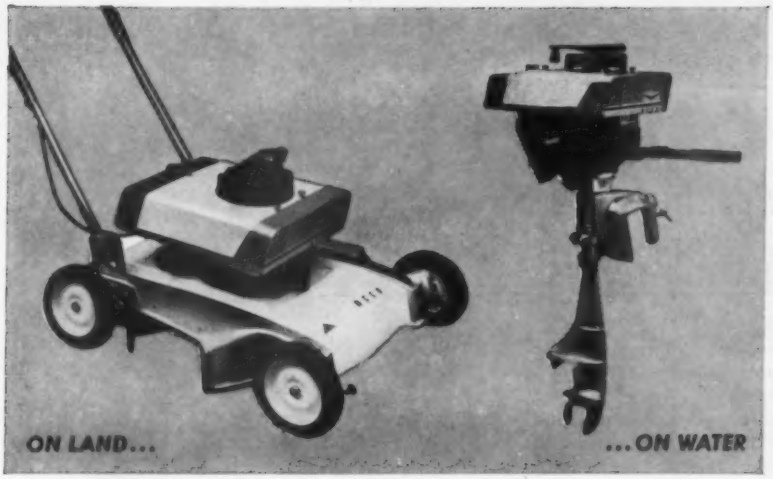
Pro-fax has opened up a whole area of new thermoplastic usage. Now designers have at their command a structural material that can often be used to replace more costly raw materials. Easy to mold, Pro-fax can be used to produce precision-formed units at low cost. It's little wonder that so many of the nation's leading appliance manufacturers are turning to Pro-fax to help solve production problems, and to give added values to their products.

## A TRIPLE PLAY BY PRO-FAX

This Triple Duty Filter Dispenser, an exclusive feature found in all Philco-Bendix "Automagic" washers, is another example of the advanced engineering made possible by the proper use of such new plastics as Pro-fax polypropylene. Exploded view (left) shows the six injection-molded parts which make up the assembly of this compact, highly functional unit. Removable cap and cup shown at top are polyethylene. The remainder of the unit consists of four precision-molded Pro-fax parts which are ingeniously joined to form the body of the dispenser filter. The dispenser lid is permanently joined to the upper half of the body by spin-welding, while the lower half is attached by self-tapping screws. The removable filter trap (at bottom) has a molded bayonet-type catch, with an insert-molded metal mesh filter. Pro-fax was selected for this demanding assignment because of its outstanding resistance to detergents and chemicals, and its ability to withstand prolonged exposures to high temperatures. Lightweight; a handsome, colorful finish; and resistance to breakage are other features of the new unit. And of course the producer enjoyed all the important processing bonuses provided by Pro-fax, including more parts per pound, and dimensionally stable, precision fitting components.

Instantly accessible when the washer is open, Philco's Triple Duty Dispenser serves three important functions in the washing cycle. The entire tub of water is filtered six times a minute to remove all traces of lint. It provides automatic detergent dispensing at any preselected water level, insuring even dispersion; and it automatically dispenses clothes conditioner at the proper time to assure a softer, cleaner wash.

*Molded by Seneca Plastics Company, Cambridge, Ohio.*




## DOUBLE PLAY BY ACCO

The new Acco "Outboard Mower" is not only an industry first, but one of the first big new merchandising ideas of many a year. It's a power mower with a motor that can be removed and attached to a propeller unit to make a powerful outboard motor. The conversion can be effected in minutes, and on land or water the motor is protected at all times by a colorful, durable housing molded with Pro-fax. Pro-fax proved the only plastic with all the requirements demanded by this new concept in dual-purpose equipment: lightweight, rigidity, resistance to heat, chemicals and staining, plus a lustrous surface finish that bespeaks quality merchandise.

*Molded by Research Plastics, Inc., Jersey Shore, Penna.*

## A HIT BY REGINA

This attractive, low-cost plastic accessory is certain to be a hit with homemakers who own a Regina Polisher-Scrubber. Waxing is no longer a chore with this new automatic dispenser unit. Fingertip control assures uniform distribution of wax, avoiding waste and yielding professional results without splashing or stooping. For the ultimate in appearance and performance in this new appliance accessory, Regina selected Pro-fax. In addition to providing lightweight strength in a handsomely styled unit with a colorful, stain-proof finish, Pro-fax supplies the excellent sealing qualities needed for a leak-proof seal, plus resistance to wax solvents such as turpentine.

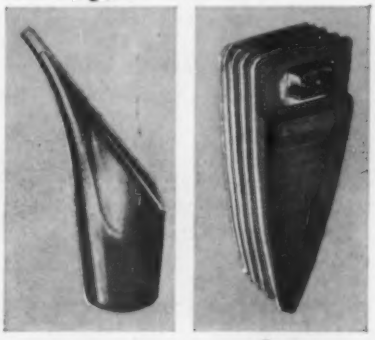
The new Pro-fax pump unit is easily attached to the Regina Polisher-Scrubber handle. When not in use, it will not hamper normal operation.

*Pump unit molded by Ideal Plastics Division, Ideal Toy Corporation, Long Island, New York.*

## Design Hi-lites

The dramatic change-over by producers of light-duty liquid detergents to blow-molded plastic bottles has focused new attention on a long-established processing technique. Blow-molding is one of the oldest of plastic arts, and designers have long been intrigued by the intricate shapes and unusual forms which can be achieved by this method. Until recently, however, materials adaptable to blow-molding lacked the structural and functional characteristics required to yield rigid structures suited to a wide range of uses. The advent of such new plastic materials as Hi-fax, high-density polyethylene, has changed this picture to the point where blow-molding has now become the fastest growing sector of our industry.

**Permitting the use of undercuts, blow-molding can achieve intricate shapes impossible by other methods. Modern version of classic vase in design below could serve as watering can, condiment bottle, or medicinal container. Sketches by Sundberg-Ferar.**



**Blow-molded Hi-fax containers can be designed with a "bellows" action in packages that serve as pumps or dispensers. Design shown above is for a household deodorant or insect spray container.**

The sketches shown here are but two of the many exciting and different product ideas shown in a new Hercules film-strip, "Something New in Packaging." If you'd like to see this up-to-date report on a new industry and the materials which serve it, write or call us. It will take only minutes of your time, may put your new products years ahead.

CP60-3

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THREE NEW MATERIALS FOR THE PLASTIC INDUSTRY

HI-FAX® HIGH-DENSITY POLYETHYLENE • PRO-FAX® POLYPROPYLENE • PENTON® CHLORINATED POLYETHER

HERCULES

For more information, turn to Reader Service card, circle No. 483

## ECONOTAPE crossbar contacts are most efficient for electrical relays

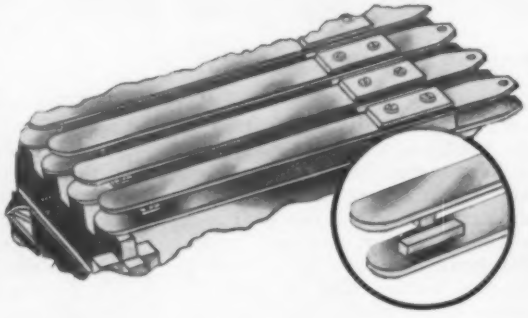
D. E. MAKEPEACE DIVISION

You can now get ideally efficient crossbar contacts for your electrical relays—with as many contacts as you need, where you need them—with positive assurance of full, contact surface. This has been made possible through the development of Makepeace's new ECONOTAPE, a precision-drawn shaped or rectangular contact wire in either solid precious metal or in laminated metal—in your choice of gold, platinum, palladium, silver and their various alloys.

Econotape crossbar contacts are supplied complete, attached to Makepeace blades... attached to blades supplied by you... or Econotape for your own attaching.

Econotape is cut off and welded to the blade in one operation. It is no longer necessary to handle and attach individual button type contacts. Positioning of Econotape on the blade is done automatically as the tape is cut off and welded. Permanent attachment is assured by a homogenous metallurgical bond that is undisturbed by expansion and contraction caused by temperature changes.

If you are designing a new relay or trying to cut the cost of your present mechanism, send for Econotape literature.



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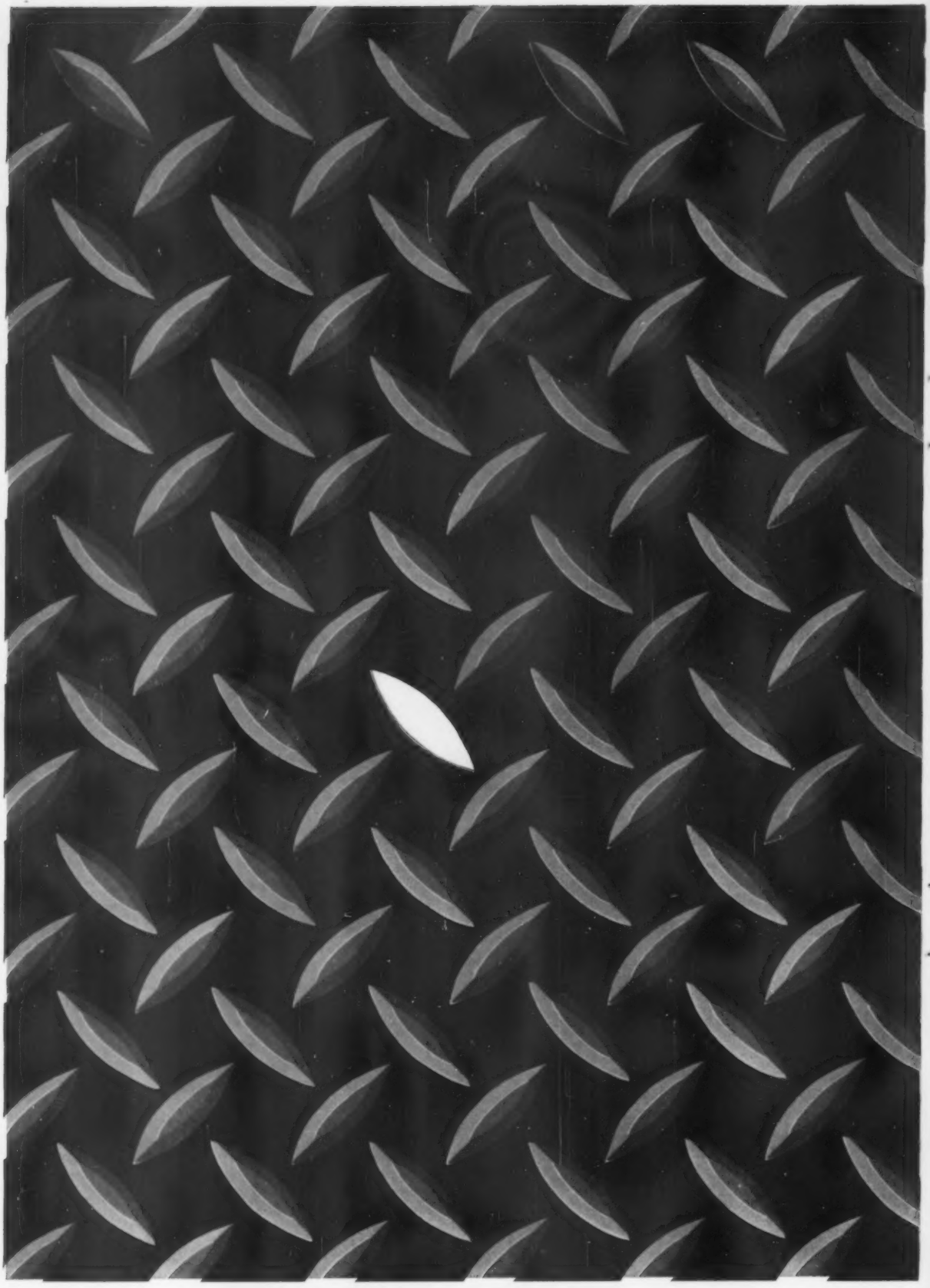

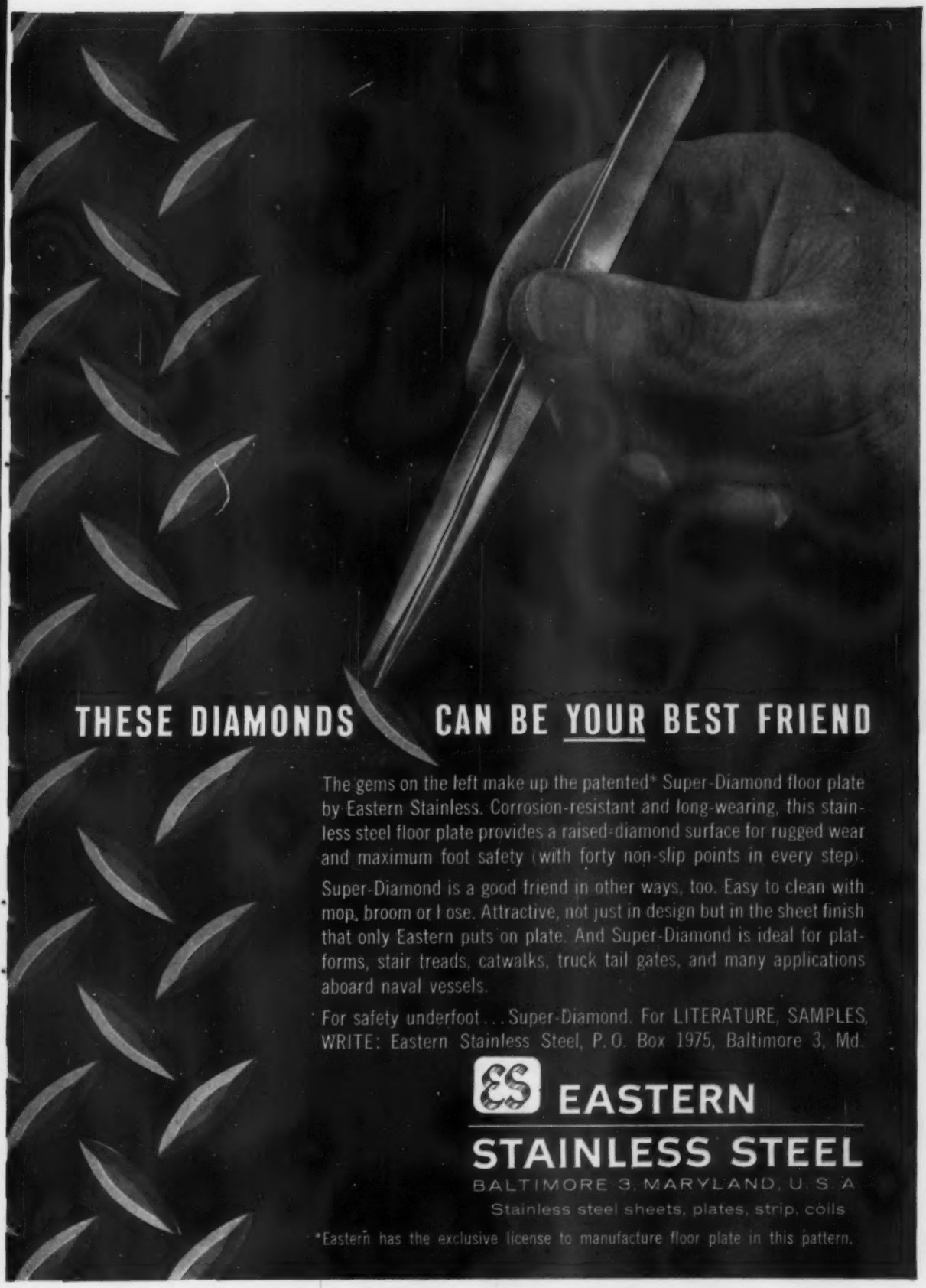

# THESE DIAMONDS CAN BE YOUR BEST FRIEND

The gems on the left make up the patented* Super-Diamond floor plate by Eastern Stainless. Corrosion-resistant and long-wearing, this stainless steel floor plate provides a raised-diamond surface for rugged wear and maximum foot safety (with forty non-slip points in every step).

Super-Diamond is a good friend in other ways, too. Easy to clean with mop, broom or hose. Attractive, not just in design but in the sheet finish that only Eastern puts on plate. And Super-Diamond is ideal for platforms, stair treads, catwalks, truck tail gates, and many applications aboard naval vessels.

For safety underfoot... Super-Diamond. For LITERATURE, SAMPLES, WRITE: Eastern Stainless Steel, P.O. Box 1975, Baltimore 3, Md.

**EASTERN STAINLESS STEEL**

BALTIMORE 3, MARYLAND, U.S.A.

Stainless steel sheets, plates, strip, coils

*Eastern has the exclusive license to manufacture floor plate in this pattern.

For more information, turn to Reader Service card, circle No. 360

# This Casting...Rotten to the core!

*Corrosion* . . . unnecessary, wasteful, representing billions of dollars to American industry. Focus on the problem begins with the early design and development of your product. Answers are found after a critical study of the corrosive environment to which your product will be exposed.

Castings are our business . . . *corrosion-resistant* castings . . . metals specifically created for you. From the blueprint to the finished casting, Waukesha provides the facilities, technology and nearly a half century of experience. Waukesha's metallurgical staff is always available to discuss your casting problems. A Waukesha consultant is as near as your phone.

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*Manufacturers of corrosion-resistant castings, inclusive of non-galling alloys, Stainless Steel, Waukesha Metal, Monel, Pure Nickel, Inconel, Ni-Resist, plus special Nickel-Chromium Alloys for specific applications.*

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DEPENDABILITY, ECONOMY and STRENGTH are distinguishing characteristics of these sintered metal automotive transmission parts by Delco Moraine. Vital components such as these are typical results of close collaboration between Delco Moraine and its customers—an effective liaison that operates from idea through design and development. They also attest to Delco Moraine's equally important capabilities for making deliveries in quantity and on time!

**DELCO MORAINE**

*DEPENDABLY MADE parts for industrial progress • Division of General Motors, Dayton, Ohio*

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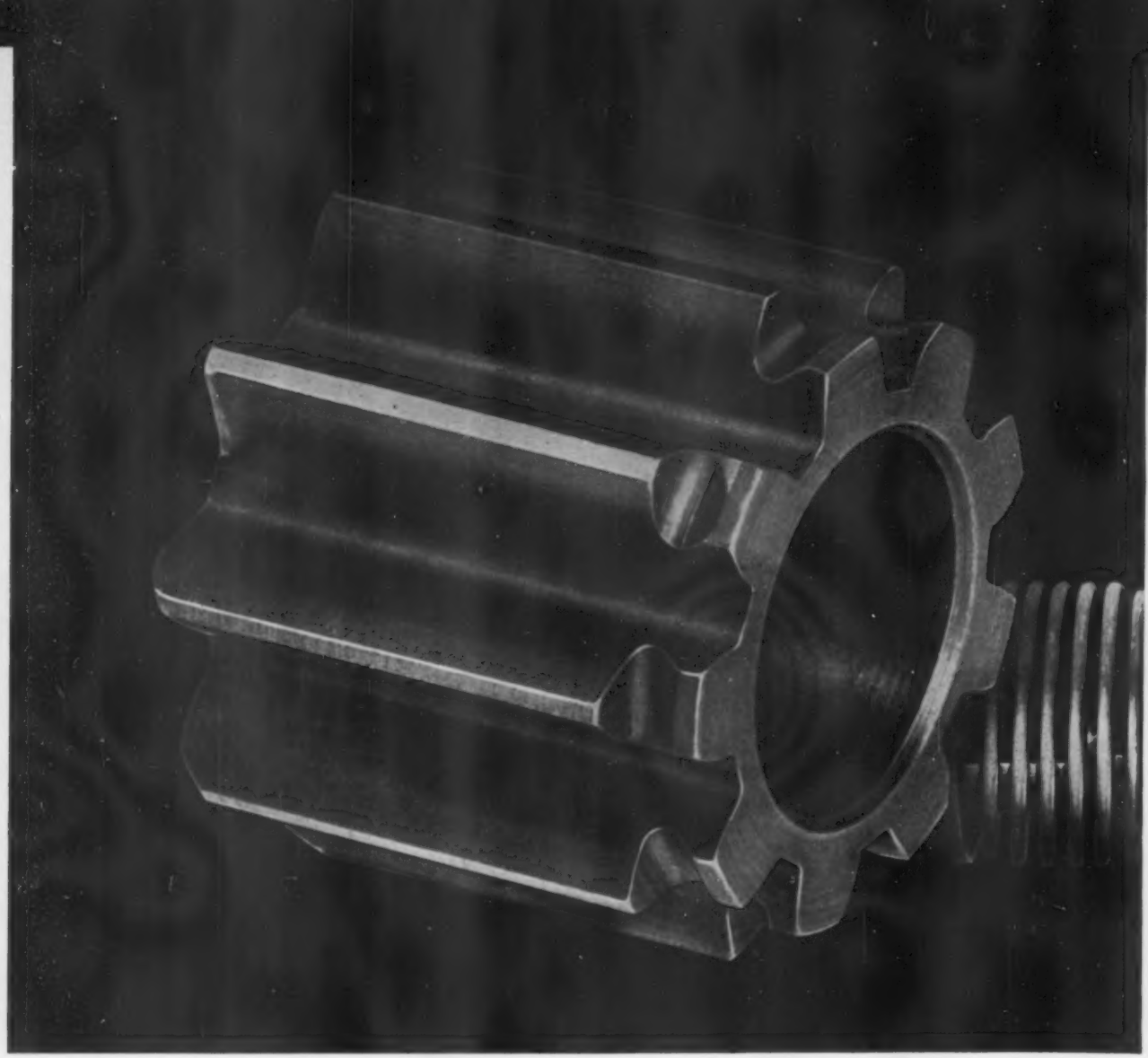
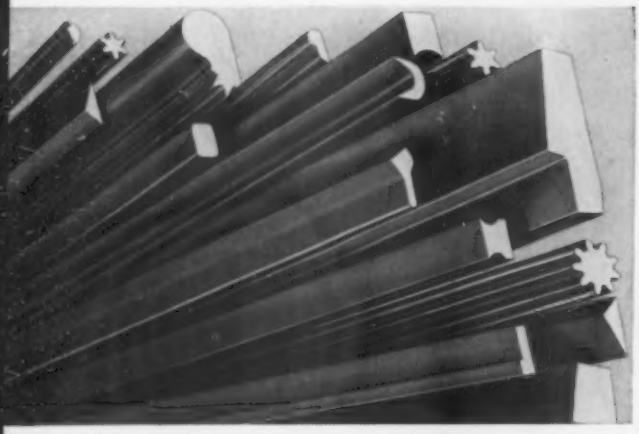


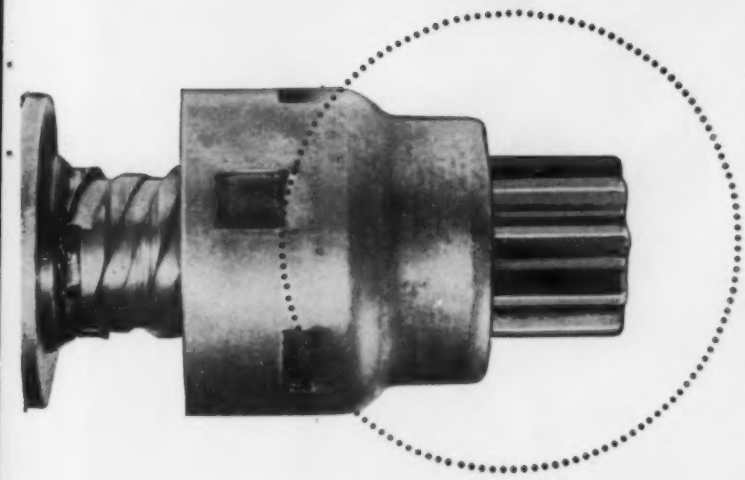


**ONE-PIECE SHAPES REPLACE COSTLY ASSEMBLIES** when Republic Cold Drawn Special Section Bars formed to the predominating cross section of the part are used. Completed parts are stronger, longer wearing, and cost less. Republic Special Sections simplify built-up, interlocking, or associated parts . . . are available in carbon, alloy, and stainless steels.

**SIMPLIFIED TUBULAR PARTS PRODUCTION** results from use of Republic ELECTRUNITE® Mechanical Tubing. With uniform wall thickness, concentricity, strength, and ductility, ELECTRUNITE Round Mechanical Tubing is easily flanged, swaged, flattened, spun, fluted, configured, rolled, upset, and otherwise changed in cross section. Mail coupon.

# SOLVING THE PROBLEM

## Alloy steel starter drive pinion withstands severe torque, impact, wear

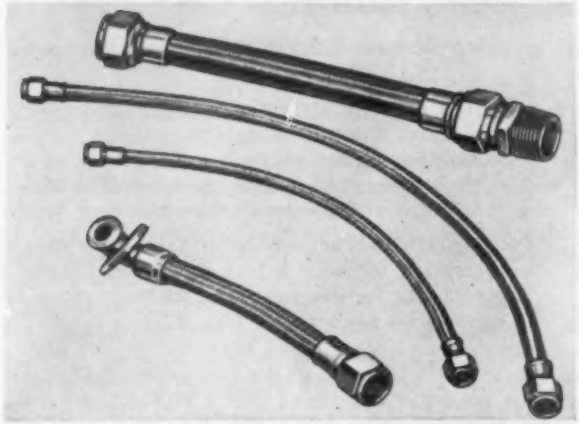


One of the largest manufacturers of automobile starter drives specifies Republic Cold Drawn Alloy Steel Bars for their most critical component—the drive pinion.

Following delivery, the cold finished alloy bars are blanked, hobbed, chamfered, and drilled. Teeth are cut on a gear hobber, then pointed for easy meshing with the flywheel.

Use of Republic Alloy Steel provides the necessary strength and toughness to withstand torque, impact, and prolonged wear. In addition, the cold drawn alloy used provides better machinability at reasonable cost.

Republic field metallurgists will work closely with your metallurgists and engineers. 3-Dimensional Metallurgical Teams, comprised of field, mill, and laboratory metallurgists, will help you select, apply, and process the right alloy steel for any application. Write today or mail the coupon for complete information—without obligation—on this confidential service.



**HIGH PRESSURE FITTINGS**—sockets, nipples, flanges, elbows, and swivel nuts—to handle missile and aircraft fuels are produced by Resistoflex Corporation, Roseland, New Jersey. Fittings are machined from 3/8" and 2" diameter Republic Stainless Steel Bars to assure maximum strength, corrosion-resistance, and machinability.

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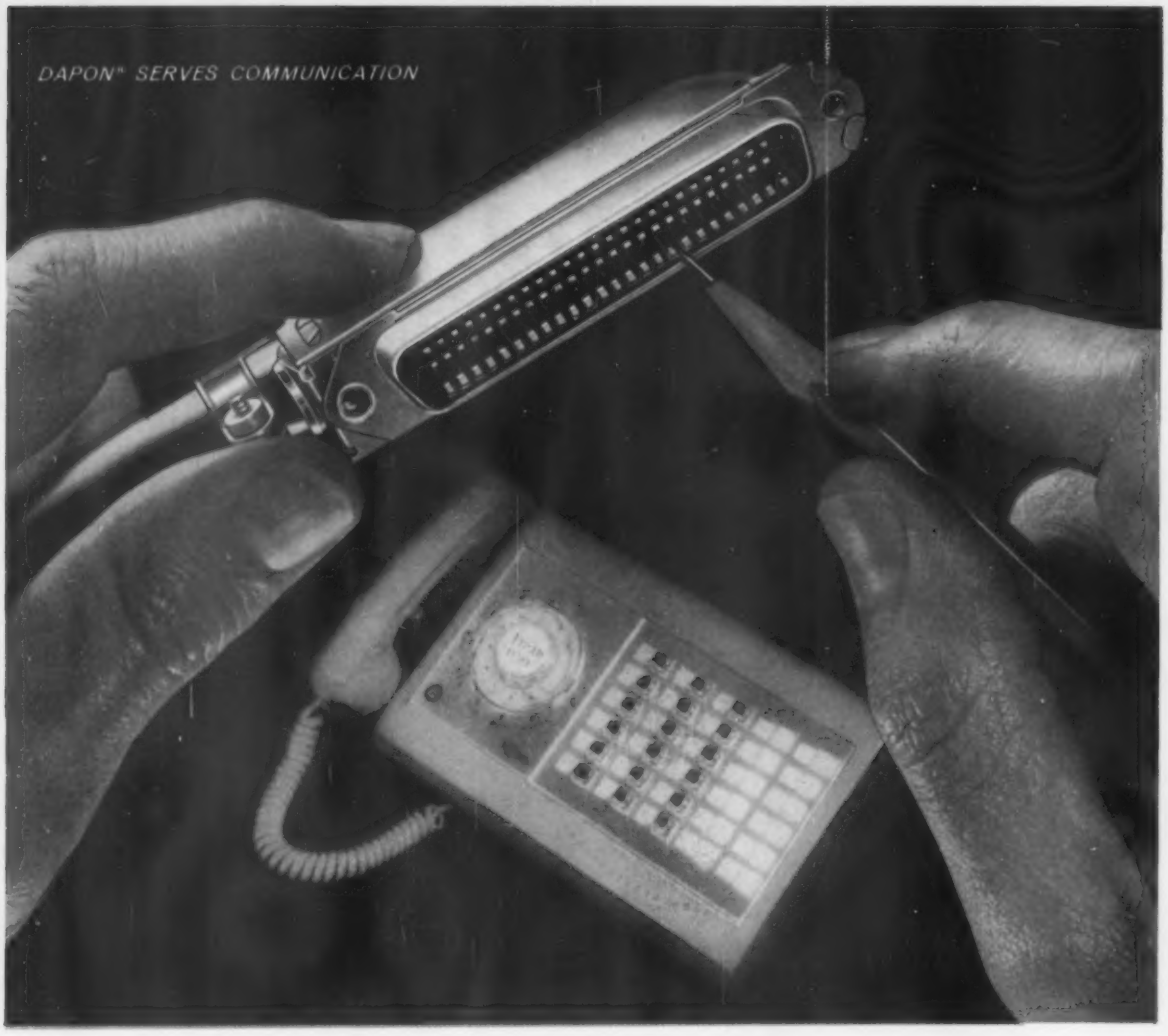


# DAPON (diallyl phthalate) RESIN GIVES A LIFETIME SHRINKAGE VALUE OF .001 IN THIS AMPHENOL CONNECTOR

***This connector routes many circuits in the Bell System's multi-line "Call Director" at a great saving of space and weight.***

About the size of a cigarette lighter, an Amphenol-Borg Electronic Corporation connector is used in the Bell System's "Call Director." This versatile telephone can handle as many as 29 outside lines or extensions. The working members of this connector are fifty gold plated bronze contacts held firmly in a body molded from DAPON (diallyl phthalate) Resin.

Chosen by Amphenol for this application because of its dimensional stability and insulating properties, DAPON's superior moldability accommodates the thick and very thin sections and lateral cavities of the connector's body. DAPON molds easily around metal inserts; there is no cracking and little or no after-shrinkage of DAPON molded parts after years of service, even under elevated temperatures.

Specify DAPON (diallyl phthalate) Resin when you need:

- Low dielectric loss
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Write to the address below for FMC's data sheet containing technical information about DAPON, suggested uses for this resin, and the name of the DAPON compounder nearest you.

FOOD MACHINERY AND CHEMICAL CORPORATION
**Dapon Department**
161 East 42nd Street, New York 17, New York

For more information, turn to Reader Service card, circle No. 491

# ASSIGNMENT: CORROSION

## How Lukens *Application Research* can help you find the right steel plate for the job

Migrating ions—superimposed on a photomicrograph of corroded steel plate—symbolize one of metallurgy's oldest assignments: the battle against corrosion. Developing new tactics in this constant campaign is the job of our Application Engineering staff.

For example, called on early in the planning stages, Lukens engineers recently attacked almost identical problems for two large processing companies—and came up with two completely different solutions.

The first involved a sugar refiner's vacuum pans. Frequent and costly cleaning was required to head off corrosion and product contamination. Our staff's prior research and experience in the food equipment field led it to suggest *nickel*-clad steel for the pans. (13% and 8% nickel-clad on A-285 backing steel.)

Cleaning and maintenance were equally costly to a leading chemical and dye company—in the protection of its nitrogen solution barge tanks. Here, our engineers found *stainless*-clad steel the most desirable answer. (12% 304L on A-212 backing steel.)

Armed with practical as well as technical knowledge of Lukens' wide range of special-duty steels, our Application Engineers have helped conquer corrosion on many fronts. That's why we say . . . *if your assignment is corrosion, let it be our assignment, too.* Contact Manager, Application Engineering, D-40 Services Building, Lukens Steel Company, Coatesville, Pa.

**Helping Industry Choose Steels That Fit The Job**

LUKENS

**ASK FOR THE BULLETIN ON LUKENS CLAD STEELS**

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DIVISION OF STUBNITZ GREENE CORP. Whitmore Lake, Michigan • Phone Hickory 9-9361

REYNOLDS CHEMICAL PRODUCTS COMPANY

Today, flawless Urethane foam production is synonymous with the trade-name Reynofoam. The reason: Reynolds Chemical, a pioneer in foam development today delivers foam products round-the-clock, in multi-shift production. Cored or uncored, your foam seating needs will be better served if you look to Reynofoam-answer to foam requirements of the seating industry.

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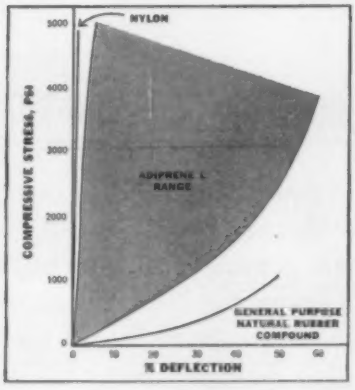
# ADIPRENE® L

*new Du Pont liquid urethane elastomer*




**CARRIES A HEAVY LOAD** An outstanding attribute of this new Du Pont synthetic rubber is its combination of toughness, high load-carrying ability and resilience. Load-bearing capacities of hard ADIPRENE L compounds far excel those of general purpose synthetic rubbers.

**RESISTS ABRASION** Both in the laboratory and in actual service, ADIPRENE L has demonstrated its ability to resist wear. On industrial wheels it has outlasted natural rubber as much as 10 times . . . has more than doubled service in pump impellers handling abrasive slurries.

**NOT BRITTLE AT "EIGHTY BELOW"** ADIPRENE L vulcanizates maintain their resilience at –20° F. . . . and do not become brittle at temperatures as low as –80° F. They exhibit outstanding resistance to thermal shock, and will operate at intermittent temperatures as high as 250° F.

**OTHER PROPERTIES** Products made from ADIPRENE L are available in various hardnesses from 10 to 99 Shore A (78 Shore D). They resist the action of lubricating oils, greases, weak acids, alkalies, as well as oxygen, ozone and radiation. Suggested uses for ADIPRENE L include industrial rolls, motor mounts, seals, potting compounds, solid tires, striker plates, wear-resistant linings and coverings. Write for booklet on properties and applications of this new material. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. ME-4, Wilmington 98, Delaware.

DU PONT **SYNTHETIC RUBBER**
NEOPRENE HYPALON® VITON® ADIPRENE®
Better Things for Better Living . . . *through Chemistry*

For more information, turn to Reader Service card, circle No. 325

# NEWS FROM GOODRICH-GULF

## NEW HIGH-DENSITY POLYETHYLENE TO HAVE UNIQUE CHARACTERISTICS

**A new type of high-density polyethylene not now manufactured in the U. S. will be produced in a new Goodrich-Gulf plant, scheduled for completion late this year. The product will be the first of a family of polyolefins.**

**Specific characteristics, including outstanding environmental stress crack and thermal resistance, have been built into the Goodrich-Gulf polyethylene which will be manufactured by a new process based on Ziegler chemistry. This process has been developed during four years of pilot plant operation and is designed to produce ethylene polymers particularly suited for manufacturers of bottles, pipe, wire and cable insulation.**

**Goodrich-Gulf work on plastic materials has covered the entire range of polyolefins with special emphasis on polymers of ethylene, propylene and butylene. Development laboratory and complete sales service will be provided in conjunction with the new plant.**

## NEW AMERIPOL 4600 IS EASIER PROCESSING RUBBER

A new, fatty acid emulsified, cold type styrene-butadiene copolymer is now available from Goodrich-Gulf. Called Ameripol 4600, the announcement of its development is being made after a year of extensive field testing, which indicates that it will be ideal for use in shoe soles, floor tile, sponge, white sidewalls, sport shoes and household goods.

Ameripol 4600 is similar to 1502 type polymer except a fatty acid emulsifier is used instead of mixed fatty acid rosin soaps. However, 4600 has some distinct advantages: its Mooney is in the 36-48 range rather than 46-58 and it is lighter in color.

The new polymer was produced primarily to provide rubber processors with an easier processing rubber exhibiting a faster cure rate, higher modulus, and less tack than 1502. With lower viscosity, the polymer can be broken down in drastically less time than usual. The reduced Mooney range also provides less power consumption at the processor's plant. The hardness of 4600 is slightly higher than 1502 for a given cure time.

Exceptional appearance and smooth feel are achieved in these soles for quality dress shoes with Ameripol 4600. In addition, processing costs are reduced.

## LOOK AHEAD-NEW SYNTHETIC RUBBERS FOR TRUCK, AIRCRAFT, HEAVY VEHICLE TIRES

Advanced engineering work is underway at Goodrich-Gulf leading toward commercial production of two new synthetic rubbers, Ameripol SN rubber (polyisoprene) discovered by the company in 1954, and Ameripol CB (cis-polybutadiene) rubber, an equally important development.

Ameripol SN, the first man-made rubber having the same molecular structure as natural tree rubber, was first announced by Goodrich-Gulf in 1954. It possesses the physical properties of tree rubber even to tack and stickiness. Pilot plant operation has produced five distinct types in tonnage quantities for large scale testing. This program has demonstrated that Ameripol SN can be substituted pound for pound for natural rubber in the manufacture of truck, bus, aircraft, military, and off-the-road tires.

Ameripol CB rubber has excellent characteristics for minimizing heat build-up, which is a prime cause of the destruction of truck tires and other products. It is a stronger, tougher rubber at high temperatures than any other general purpose synthetic rubber now available.

When these new rubbers are available, it is anticipated that manufacturers of heavy-duty tires can reduce their dependence on tree rubber by 50 to 100 per cent. In addition to attractive physical properties, these new man-made rubbers will offer the major advantages of price stability and a source of supply completely independent of far eastern sources.

## CONVEYOR USES WORLD'S LONGEST RUBBER BELT

**Ameripol rubber is used in eleven miles of conveyor belting for this limestone and shale conveyor system—including a single flight of belting measuring nearly 12,000 feet, longest ever built. Long length belts help reduce maintenance, labor and equipment costs.**

**Ameripol is a preferred rubber for the blend used for belting material. It contributes good aging properties, and resistance to wear and weathering.**

Ameripol
THE PREFERRED RUBBER

## SALES SERVICE LABORATORY EXPANDS FACILITIES

**This Banbury® Mixer at the Goodrich-Gulf Service Laboratory is typical of a full range of processing equipment which helps us duplicate customer factory operations. Thus, problems can be analyzed thoroughly and sound technical recommendations for different recipes, processing methods, etc., can be made. Laboratory services, when you need them, are available through Goodrich-Gulf Technical Service.**

**If you want additional information on any of these items, or would like to be on the Goodrich-Gulf technical release mailing list, please write Goodrich-Gulf Chemicals, Inc., 1717 East Ninth Street, Cleveland 14, Ohio.**

# Goodrich-Gulf Chemicals, Inc.

For more information, turn to Reader Service card, circle No. 477

3M COMPANY CHEMICALS THE RAW MATERIALS OF PROGRESS

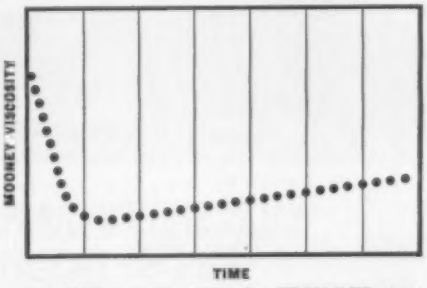
# NEW FLUOREL® 2141

## BRAND ELASTOMER

*Its Mooney Scorch Rating is ideal for the fluorinated rubber processor because it makes possible fast, more economical cures with fewer defects, less scrap, fewer rejected parts. Material can be reprocessed with greater safety.*

**A SIGNIFICANT BREAKTHROUGH** in elastomer processing has been made possible by 3M research through development of its new FLUOREL 2141 Elastomer.

This remarkable new product has a Mooney Scorch Rating outstanding among fluorinated elastomers. The range permits the rubber processor to achieve fast, more economical cures with fewer defects, less scrap and fewer rejected parts. The inherent safety of FLUOREL Elastomer 2141 allows repeated reprocessing to produce high quality parts that meet military specifications or other critical end uses.




**MOONEY SCORCH CURVE** for FLUOREL 2141 Brand Elastomer.

At the same time, the outstanding physical qualities of the elastomer are retained. They include: non-combustibility, excellent resistance to corrosive chemicals, fuels, solvents and ozone, minimum compression set, rated for continuous service at 400° F., and the ability to tolerate 600° F. temperatures for reduced periods under certain service conditions.

If you use or work with elastomeric materials, it will pay you to examine the remarkable features of this new product. Examine, too, your present rubber products with an eye toward increasing their life and quality through use of FLUOREL 2141 Elastomer. For complete data, write today on your company letterhead to: 3M Chemical Division, Dept. KAR-40, St. Paul 6, Minnesota.

**FLUOREL** 2141 "O" ring, bottom. Note freedom from defects because of the improved scorch characteristics of FLUOREL Elastomer "O" ring as opposed to elastomer at top of photograph.

"FLUOREL" is a reg. T.M. of 3M Co.

**CHEMICAL DIVISION**

**MINNESOTA MINING AND MANUFACTURING COMPANY**

**...WHERE RESEARCH IS THE KEY TO TOMORROW**

3M COMPANY

For more information, turn to Reader Service card, circle No. 346

For more information, circle No. 456

# WE BREAK BOTTLENECKS

Jervis quality metal stampings are supplied to the automotive, appliance hardware, and marine hardware industries.

Contact Jervis and add eight acres of high-volume metal stamping equipment to your production line. Sixty presses, ranging in capacity from five tons to two thousand tons, are only a part of the Jervis set-up. Die space on these presses goes up to thirty-six inches. Bed area is as high as sixty inches by sixty inches. Buy quality metal stampings. Bring your specifications or blueprints to Jervis for an estimate that will break your production bottleneck. For complete information about Jervis operations (stamping, casting, finishing, assembly), write for free color brochure "This is Jervis." JERVIS CORPORATION, Grandville, Michigan.

JC JERVIS CORPORATION

# IF CUSTOM PARTS ARE YOUR PROBLEM

## Sylvania can solve it with complete QC* service

**Helps you** with completely objective recommendations for your parts. Sylvania is backed by long experience in metals, plastics, welds and assemblies, can produce parts utilizing a wide range of equipment.

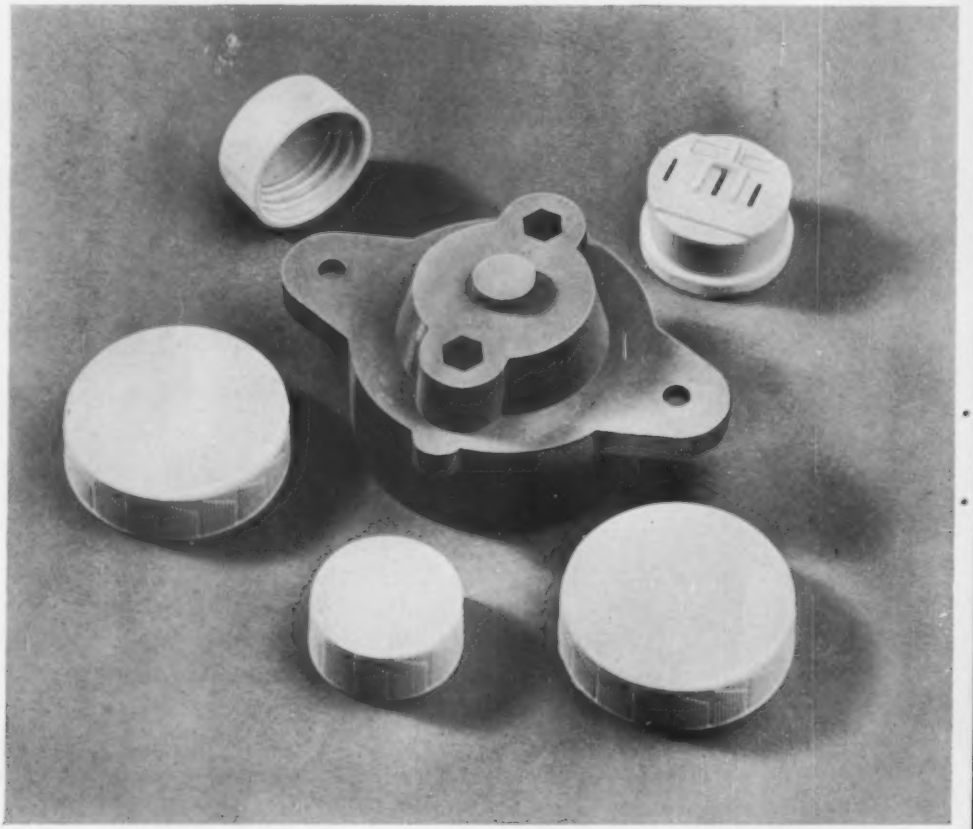
**Offers design assistance** that can often improve the quality of your part, lower production costs.

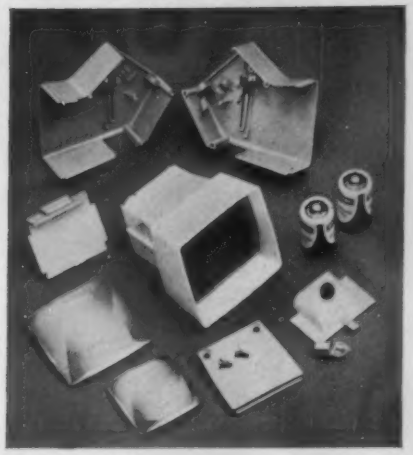
**Provides superior quality parts.** Sylvania utilizes the most modern equipment available, and its experience in tooling means better quality at lower costs for finished parts. In addition, Sylvania practices preventive maintenance for dies and equipment to assure you precise uniformity and uninterrupted production.

### MOLDED FROM PLASTIC

Sylvania offers "total" low piece prices. Reason? It operates probably one of the most complete lines of modern automatic molding equipment in the world for compression, injection and transfer molding. Its bank of rotary presses can produce more than a million parts a day, is ideally suited to phenolics and urea, and assures minimum cost for simply designed plastic parts.

Results: your plastic parts —in volume—are produced quickly and at low cost.





## FORMED FROM METAL

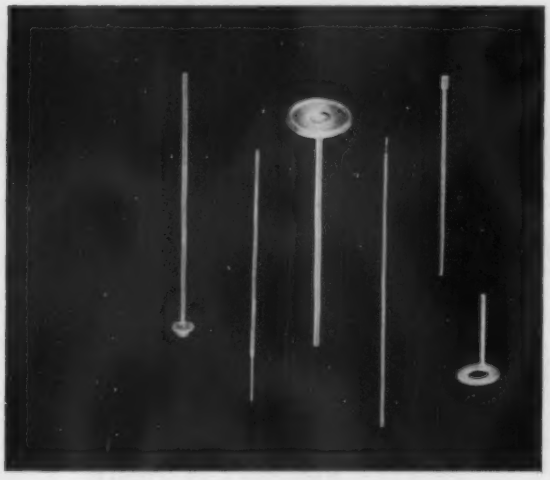
Sylvania maintains custom metal stamping facilities, can produce millions of precision-made parts each day from all types of metal. The scope and flexibility of these facilities mean that it can deep-draw eyelets, shells, cups and ferrules. What's more, a battery of multi-slide machines can produce more than 2 million parts daily. Vertical presses can meet daily production needs of 2 million parts. And special, Sylvania-developed machines can produce great quantities of small wire and ribbon forms as well as wire cuts and leads.

Results: Sylvania can supply the parts you need—in high production quantities—of top quality—and at lower cost.

## CUSTOM ASSEMBLED

Many of our customers have analyzed their parts assembly needs. And they have discovered that Sylvania can often deliver a completely assembled and packaged product—using either all Sylvania components, all customer components or both—at lower cost than is possible within the customer's own facilities.

Result: If your product is small, the parts predominantly plastic and metal, and the quantities 50,000 or more, it pays to have Sylvania assemble it.



## CUSTOM WELDED

If your part is standard-sized, miniature or subminiature, welded assembly is a Sylvania specialty. To help meet your custom assembly needs, Sylvania has developed new high-speed, high-volume welding techniques, advanced welding equipment, automatic and semi-automatic, and a corps of trained specialists.

Result: Sylvania welded assemblies assure high-quality electrical and mechanical contact, mirror-image uniformity, low cost.

## *QC MEANS QUALITY CONTROL!

Sylvania maintains a complete quality control department to assure that parts are made to your exact specifications. This control works for you throughout the manufacturing cycle. It's just one more way you benefit when you have Sylvania on the job.

For full details or a quote, write Sylvania Electric Products Inc., Parts Division, Warren, Pa.

# SYLVANIA

*Subsidiary of* **GENERAL TELEPHONE & ELECTRONICS**

For more information, turn to Reader Service card, circle No. 495

# R B&W FASTENER BRIEFS

MAKING THE MOST OF MODERN MECHANICAL FASTENING

## *Technical-ities*

By John S. Davey

### Quick facts on cold heading

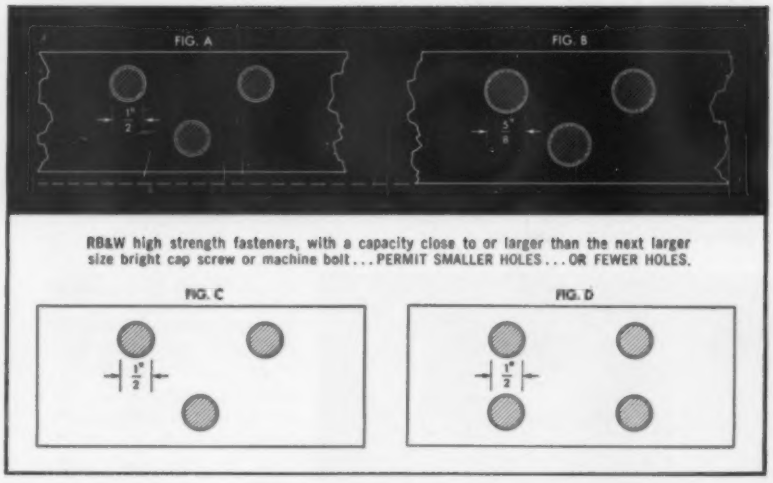
Compared to machining, cold heading gives stronger pieces at less cost. Also, the headers automatically control quality because unsound material cannot be used. While the scope of cold headers is wide indeed, it pays to design for them right at the start.

Some rules of thumb to guide you:

1. You save money after a run of 25,000 pieces (which pays for the set-up).
2. Maximum length of parts runs about 6 inches. Maximum volume of upset is equivalent to length of stock 4½ times its own diameter. (With special operations, up to 26 diameters have been achieved!)
3. Various metals and alloys are suitable. But keep carbon content in steel to under 0.45.
4. Concentric pieces are easier to form, though eccentric and serrated shapes are practical.
5. Avoid sharp corners. Allow generous radii.
6. Because upsets are usually cylindrical, oval or round shapes take less trimming than square or rectangular.
7. Hollow upsets tend to form cracks at edges of recess, so avoid them.
8. Embossing raises costs.
9. No problem heat treating short sections. But long sections are apt to be distorted.

When in doubt, contact an expert in cold heading.

# How high strength fasteners affect the holes they fill




RB&W high strength fasteners, with a capacity close to or larger than the next larger size bright cap screw or machine bolt... PERMIT SMALLER HOLES... OR FEWER HOLES.




As simple a matter as the selection of fasteners can permit changes for better design... and also improve production costs and service life.

In sketch "A", for example, you see one difference from use of RB&W high strength fasteners instead of machine bolts or bright cap screws, as in "B". You use a smaller size fastener. Holes are therefore smaller. The metal section, in turn, can then be smaller for a saving in material and weight. The costlier the materials (copper bus bars as a case in point), the more significant the cost savings.

In sketch "C", fill the 3 holes with ½" high strength bolts, and you have a load capacity close to 40,000 pounds. That's the same as developed by 4 bright cap screws filling holes in Sketch D. It costs less to drill and less to fill the 3-hole design.

RB&W High Strength Fasteners are now identified by this new marking as well as 3 radial dashes. They have the proper balance between ductility and hardness required in high carbon units.

**EFFECT ON PERFORMANCE AND PRODUCTION**

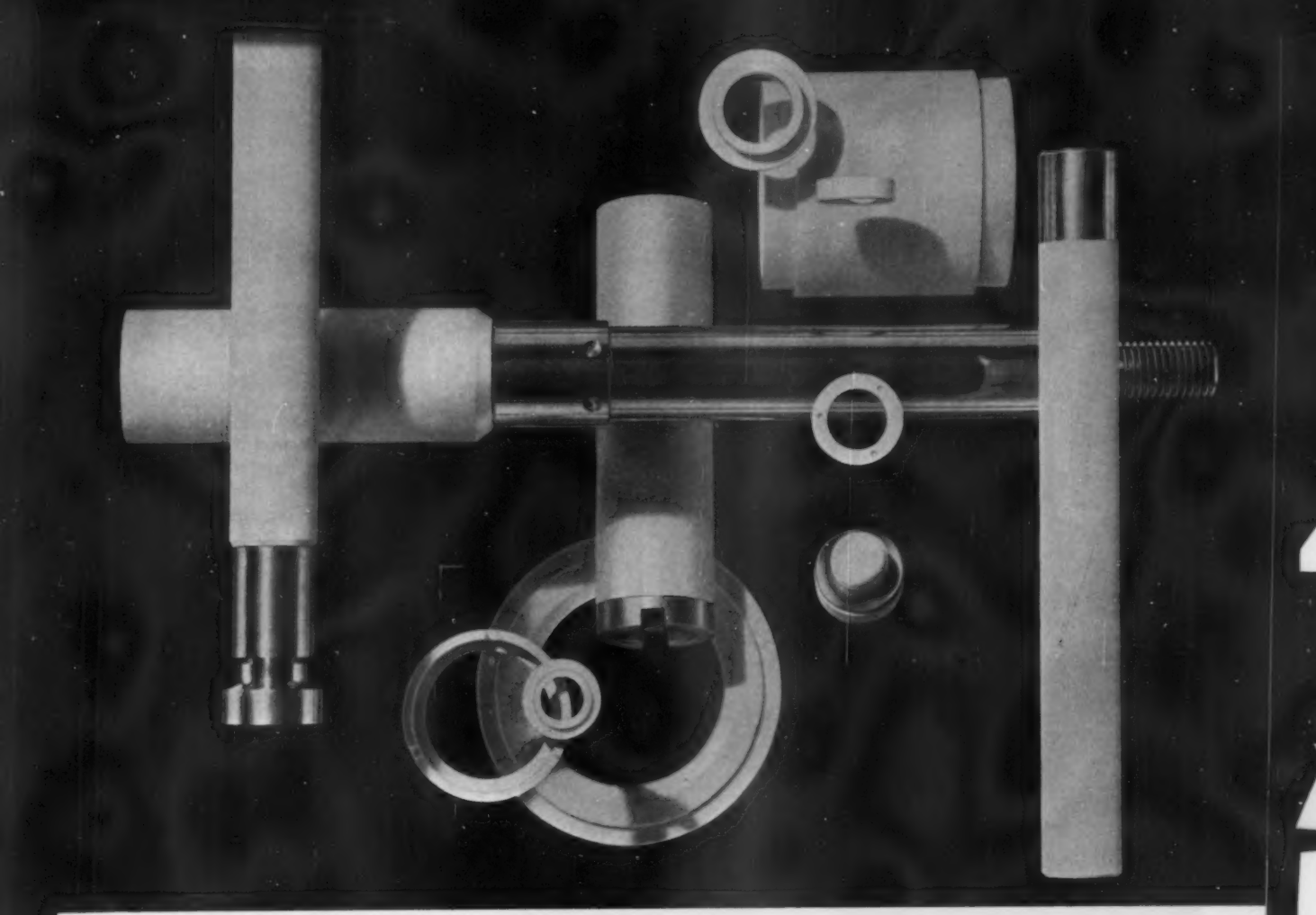
When tightened to their full load, high strength fasteners not only *stay* tight—even under vibratory conditions—but also exert high clamping force. It has been shown that, under high compressive forces, hole areas gain extra resistance to fatigue cracks.

What's more, the high friction developed virtually locks members together, prevents slippage. Holes, therefore, need not be perfectly aligned since they can even be slightly oversized without detriment.

There's an RB&W Fastener Man ready to aid you in working with high strength bolts—in the design stage or as replacement for SAE grade 1 or 2 steel fasteners or for rivets. Write for helpful booklet DC-2, Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

For more information, turn to Reader Service card, circle No. 433



# Coors Alumina Ceramics Replace Expensive Metals for Vital Pump Parts

Why? Because it is a "superb material for corrosive or abrasive conditions," according to a leading builder of large oil field pumps.

These destructive twins — corrosion and abrasion — have led pump designers to use Coors High Strength Alumina Ceramics for the vital parts of pumps, such as plungers, cylinder liners, seal faces in mechanical shaft seals, shaft protection sleeves, and ball check valves. Consequently, today you'll find Coors Ceramics in big reciprocating pumps used for oil field and industrial plant service as well as in small centrifugal pumps used in domestic hot water heating systems and washing machines.

In addition to Coors Ceramics ability to withstand corrosion and abrasion, they also have excellent strength characteristics — plus dimensional stability. They do not warp or change shape. That's one reason they are used for seal faces in shaft seals... when you lap these materials flat, they stay flat!

Perhaps your abrasive and corrosive problems can be solved economically with Coors Ceramics. We shall be glad to help you — just write us at Golden or contact one of our regional sales managers.

REGIONAL SALES MANAGERS

*West Coast*.....William S. Smith, Jr.
EM 6-8129—Redwood City, Calif.

*Midwest*.....John E. Marozeck
FR 2-7100—Chicago, Ill.

*Central*.....Donald Dobbins
GL 4-9638—Canton, Ohio

*East Coast*.....John J. McManus
MA 7-3996—Brooklyn, N. Y.

*New England*.....Warren G. McDonald
FR 4-0663—Schenectady, N. Y.

*Southwest*.....Kenneth R. Lundy
DA 7-5716—Dallas, Texas

*Oil Field Industry*.....William H. Ramsey
UN 4-6369—Houston, Texas

Coors

**COORS PORCELAIN COMPANY**

600 Ninth Street, Golden, Colorado

For more information, turn to Reader Service card, circle No. 484

# THIS IS DU PONT DELRIN®

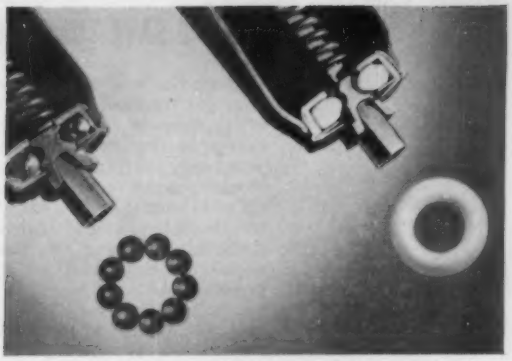
*a new engineering material offering the user distinct performance and cost advantages in many applications once reserved for metal*

Today, in hundreds of products, "Delrin" acetal resin is being used where die-cast zinc and aluminum, cast and machined brass, stainless steel and cast iron were once considered "standard". For good reasons, too: in "Delrin", these products work better, cost less to make, or both. On the opposite page, you'll find three typical examples.

The performance advantages offered by "Delrin" are based on its unique combination of properties that frequently permits parts reductions through design of multifunction parts. "Delrin" has the stiffness to remain rigid in large sections, the tensile and flexural strength to withstand high-stress loadings, the dimensional stability to hold close tolerances and the frictional properties to operate usually without lubrication. And these properties are retained even under exposure to wide variations in temperature, humidity, solvents and stress.

The cost advantages offered by "Delrin" stem primarily from its ease of fabrication, via injection molding or extrusion. These processes permit economical mass production. The need for finishing operations is usually eliminated. Part-to-part uniformity minimizes rejects. Assembly can be simplified by joining with mechanical fasteners, spin welding, snap or interference fits. "Delrin" is available in integral colors, and varied surface effects can be achieved by texturing, vacuum metalizing or painting.

We will welcome the opportunity to assist you in evaluating "Delrin" for your own product designs. A letter or the coupon at right will bring a prompt reply.



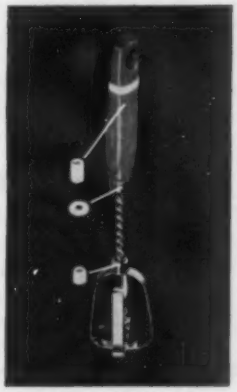
*A ring of "Delrin" replaces nine steel balls in the bearings for roller conveyors produced by the Rapids-Standard Co., Inc., Grand Rapids, Mich. These new bearings offer the advantage of quiet operation. Beyond initial lubrication, no further lubrication is required. "Delrin" was specified because of its low coefficient of friction, high strength, corrosion resistance and dimensional stability. Bearings of "Delrin" are also featured in Rapistan® wheel conveyors. (Molded by Sinko Mfg. and Tool Co., Chicago.)*

# THIS IS WHAT DELRIN® IS DOING

Now that "Delrin" acetal resin is available commercially, a rapidly increasing number of applications are going into commercial production: gears, bearings, housings, valve parts, plumbing fixtures, sporting equipment, telephone components, household items, clothing fitments and many others.

During the past three years, over 500 applications of "Delrin" were field-tested by some 250 manufacturing concerns. The success of these wide-ranging tests suggests that "Delrin" may well help you, too, improve a product, lower its costs or develop new designs for your profit. Commercial processors and our own staff of technologists will gladly provide you with more information.

*This one-hand egg beater features three parts of "Delrin" that replace a stamped brass bearing, a cold-rolled steel retainer and a brass bushing. The excellent frictional qualities of "Delrin" provide smoother, quieter operation. Tough and abrasion-resistant, "Delrin" provides a life span ten times longer than originally anticipated according to the manufacturer, Ekco Products Company, Chicago, Ill. (Molded by Vulcanized Rubber and Plastics Co., Morrisville, Pa.)*



*Flat-top conveyor chains of "Delrin" made by Fenco, Inc., Chicago, weigh only one-third as much as steel chains. Their service life is estimated at two to four times that of metal conveyors. Initial cost is 40-50% lower and little maintenance is required. The flat links of "Delrin" are strong, resistant to abrasion and corrosion, have a low coefficient of friction, require no lubrication. (Molded by Du Bois Plastics Product Company, Buffalo, N. Y.)*

**POLYCHEMICALS DEPARTMENT**

DU PONT

REG. U.S. PAT. OFF.

Better Things for Better Living . . . *through Chemistry*

*FOR MORE SPECIFIC INFORMATION MAIL THIS COUPON*

E. I. du Pont de Nemours & Co. (Inc.)
Department W-4, Rm. 2507D
Nemours Building, Wilmington 98, Delaware

I am interested in evaluating "Delrin" for the following use:

_____

NAME_____

COMPANY_____ POSITION_____

STREET_____

CITY_____ STATE_____

In Canada: Du Pont of Canada Ltd., P. O. Box 660, Montreal, Que.

For more information, turn to Reader Service card, circle No. 423

**PLASTICS**
in Design
Engineering

## HOW TO SAVE TIME AND MONEY

Choose Garlock as *the* source for all your plastic needs. They've had years of experience in injection molding, compression molding, extruding, punching, machining, and grinding of stock shapes and intricate parts. "Know-how" like this enables Garlock to recommend and furnish plastic materials *exactly* as you need them . . . without delay and at the lowest possible cost.

Garlock offers a wide selection of shapes and parts—regardless of size, tolerance, or quantity—in these engineered materials:

**Teflon**† **TFE**—contains the finest combination of chemical, electrical, and mechanical properties . . . chemically inert, outstanding electrical qualities, low coefficient of friction . . . withstands temperatures as low as −395°F, as high as +500°F.

**Nylon**—guaranteed bubble-free . . . has high tensile and compressive strength, good resistance to heat and chemicals, solvents, oils and greases, retains toughness at temperatures ranging from −40°F to +350°F.

**Polychlorotrifluoroethylene (C.T.F.E.)**—colorless, non-flammable . . . offers excellent dielectric properties, high compressive strength, resistance to chemicals, low cold flow in temperatures from −400°F to +390°F.

**Teflon FEP**—combines the exceptional properties of Teflon with the advantage of being easily melt-processed . . . **Delrin**†—offers metal-like strength and rigidity over a wide temperature range . . . **Polyethylene**—light, flexible, excellent electrical properties . . . **Polypropylene**—lightest of all known materials.

Garlock will work directly to your specifications or, upon request, will gladly assist you in product design and development.

# GARLOCK

***For complete information*** contact one of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada, or write for Plastics Catalog AD-171, The Garlock Packing Company, Palmyra, N. Y.

**Canadian Div.:** The Garlock Packing Company of Canada Ltd.

**Plastics Div.:** United States Gasket Company

**Order from the Garlock 2,000** . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

†DuPont Trademark

**For more information, turn to Reader Service card, circle No. 378**

# ENGINEERING & DESIGN

## ...AT A GLANCE

**Fatigue failure of tires** is almost certainly not caused by weakened nylon or rayon cords, recent research indicates. Fatigue failure, cause of which has not yet been determined, may possibly result from a breakdown in adhesion between tire cords and rubber. Once adhesion gives way the cords are left to flex unrestrained, and a tire may fail very quickly whether it has been used one mile or 100,000 miles.
Source: W. G. Klein, Fabric Research Laboratories, Inc., 1000 Providence Hwy., Dedham, Mass.

**Metals that can be used safely in an explosive atmosphere** of gasoline vapor include manganese bronze, phosphor bronze, aluminum bronze and beryllium copper. Unsafe metals are carbon steel, monel, carbon tool steel, stainless steel and high speed tool steel, according to the results of tests on the sparking characteristics of metals.
Source: Rpt. No. PB-151650, Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

**Nuclear powerplants with increased power output** may come out of current research aimed at finding a heat resistant fuel element material that is compatible with uranium dioxide at temperatures up to 5000 F. Four materials that show promise are hafnium carbide, tantalum nitride, tungsten and tantalum. The high temperature nuclear powerplants will be used to power rockets and jets.
Source: Rpt. No. D-262, National Aeronautics and Space Administration, Washington, D. C.

**Strength of stainless steel wire can be increased** by electropolishing. A 0.0495-in. dia type 302 stainless steel wire increased in strength from 276,000 psi to 374,000 psi after being electropolished to a diameter of 0.023 in.
Source: D. B. Darden, Southern Research Inst., 2000 9th Ave. South, Birmingham 5, Ala.

**TFE-lined pipe and fittings** were unaffected by sulfuric, hydrochloric, nitric and hydrofluoric acids after being in service for over three years at temperatures up to 500 F, according to a recent producer's study. The study also shows that TFE-lined pipe takes 25% to 50% less time to install than other types of high temperature, corrosion resistant pipe.
Source: Resistoflex Corp., Woodland Rd., Roseland, N. J.

**High purity aluminum alloy rivets** make good, general purpose fasteners for magnesium. Shear strength and galvanic corrosion studies indicate that high purity 5056, 5052 and 6061 aluminum alloys are compatible with the new magnesium-thorium alloys, as well as the conventional AZ31B magnesium alloy in the room temperature to 800 F temperature range.
Source: J. L. Nichols, Dow Metal Products Co., Div. of Dow Chemical Co., Midland, Mich.

**New data on materials for high speed aircraft** show that silicon carbide, zirconium boride and siliconized boron refractory materials withstand a Mach 2, 3800 F stream of air. Molybdenum can also withstand this fast, hot air stream when protected with a chromium electroplate, a nickel aluminide coating, a flame sprayed molybdenum disulfide coating, or a chromium diffusion coating.
Source: Rpt. No. D-190, National Aeronautics and Space Administration, Washington, D. C.

# New user reports say once again... rely on Ryerson for increased values

Here are new case histories that typify how thousands of steel and aluminum users who rely on Ryerson get *increased values* for their purchasing dollars. Individual points of difference between Ryerson and other sources may not in every case seem overwhelming—but in total they add up to an important difference in dependability, experience and capacity to serve.

**Production up 30%.** In the manufacture of this coupling, a large job shop recently switched from MT 1015 tubing to Ledloy® 170 tubing from Ryerson. Machining speed was stepped up to 170 sfm, and production increased 30%.

**Emergency needs met.** A breakdown was cutting output of a big paint producer, and the steel needed to repair the break was not available in the area. However, the required analyses and size were on hand at the nearest Ryerson plant 200 miles away —and within an hour Ryerson delivered 100 feet of this bar stock to the local airport. Three and a half hours after calling Ryerson in another state, the customer had his steel.

**Aluminum key to low-cost production.** Aluminum from Ryerson replaced chrome-plated brass on this hub for a disposable hypo needle—saving two-thirds of basic material cost plus elimination of expensive chrome plating. Machinability was equal to that of brass.

**Machined from one piece.** This jet engine replacement part was machined as a single unit from Type 416 Stainless—2⅝" Round, with excellent results and finish. Five operations were required to turn out the finished part. It was machined —blanked, drilled, threaded, and roughed out on back (square section)— from the Type 416 Stainless at *20% over recommended speeds*, using carbide tools.

**Better product appearance** and a worthwhile saving in material cost resulted when a Ryerson man recommended that a producer of portable coolers switch from one aluminum alloy (3003-H14) to another (5005-H14). Slightly higher structural strength was a bonus value. Unusually broad aluminum stocks and technical resources often enable Ryerson to serve in this way.

**PVC cuts costs 50%.** A screw machine shop recently replaced nylon with Ryertex®-Omicron PVC in the manufacture of a nipple adapter and coupling nut, and cut costs 50%. PVC machined better—to closer tolerances with improved finish . . . ran faster without "gumming." Note the perfect cutting of threads and barbs. Threads fit perfectly.

These examples illustrate some of the many advantages that make Ryerson service truly unique. A call to your Ryerson representative may solve similar problems for you.

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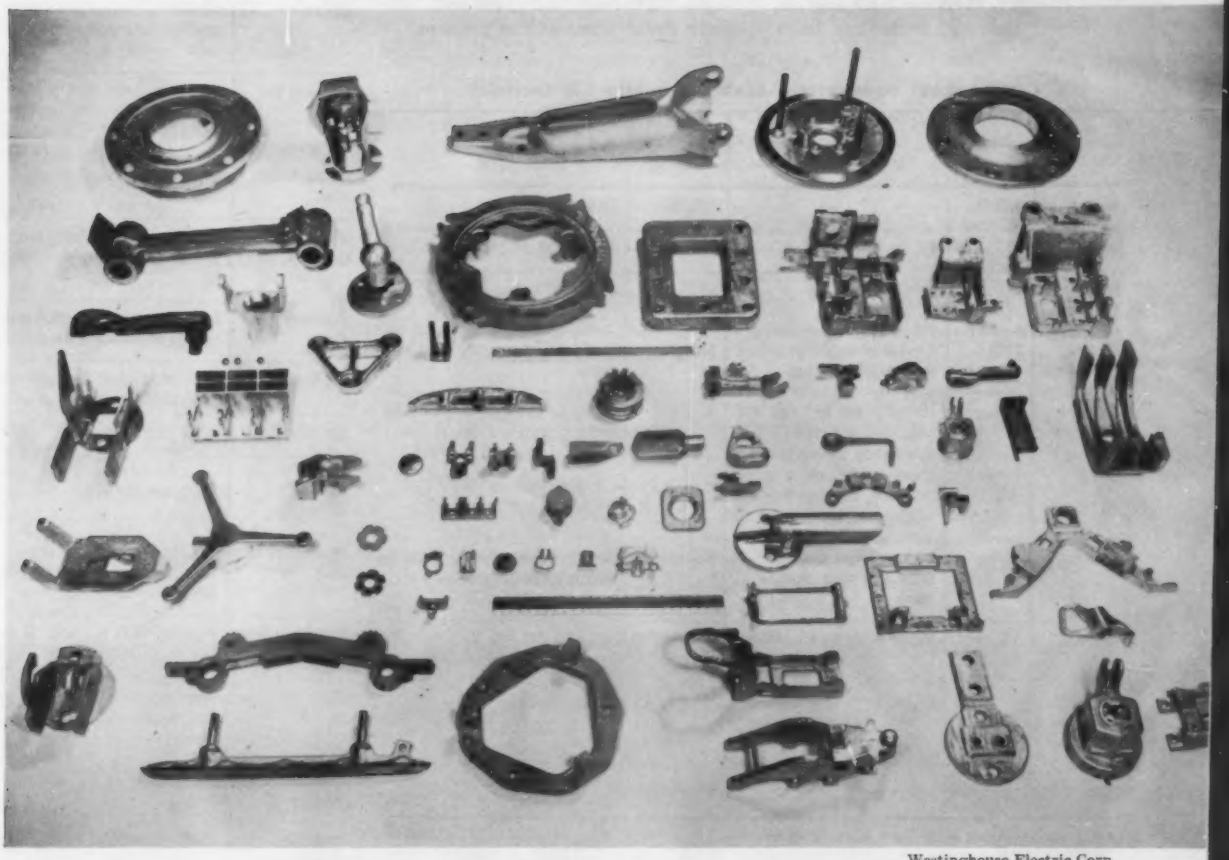


Westinghouse Electric Corp.

**Wide scope** *of gravity casting in terms of size and complexity of parts is shown by this collection of gravity die cast aluminum and copper alloy castings. Rulers are 24 in. long.*

## How to Take Advantage of

# Gravity Die Casting

*For most common metals it offers a good compromise on complexity of shape, dimensional accuracy, mold cost, direct labor cost and production rate.*

**by Donald Peckner,** *Associate Editor, Materials in Design Engineering**

■ An engineering casting may be defined, literally, as "one or more holes supported by and accurately located in a uniformly solidified mass of metal." Considerable skill is required to accurately place these holes and shape the surrounding metal so that it will allow the holes to function efficiently. Many methods have been developed over the centuries to produce engineering castings. One of the most important methods is permanent mold casting.

Essentially, permanent mold casting means casting in a mold, generally made of metal, that is not destroyed by removing the casting. Several types of casting performed in permanent molds in-

* This article is based on material prepared while the author was employed by the Materials Engineering Dept., Westinghouse Electric Corp.

clude: pressure die casting, centrifugal casting, and the subject of this article, gravity die casting.

Although much has been written about pressure die casting, sand casting, shell molding and investment casting, little has been accomplished in grouping together data on gravity die casting. The term permanent mold casting describes several casting techniques, as noted above, and the English term "gravity die casting" is more descriptive of the process.

**TABLE 1—COST COMPARISON—SAND VS GRAVITY DIE CASTINGS**

| | Sand Casting | Remarks | Gravity Die Casting | Remarks |
|---|---|---|---|---|
| Weight | 3.39/lb | | 3.01/lb | 12.4% lighter |
| Alloy | $0.15/lb | 4% Cu, 1% Si, bal Al | $0.15/lb | 4% Cu, 2% Si, bal Al |
| Heat Treatment | $0.05/lb | Soln treat and age | $0.05/lb | Soln treat and age |
| Casting Equipment | $160 | 1 match plate (2 impressions on plate); 1 core box | $700 | Complete equipment, mold and cores |
| Castings Per Hour | 20 avg | 16 molds per hr (cope and drag, gate and riser cutting, core setting, closing, pouring, shake-out); 40 cores per hr (making, setting, baking, touching up, coating) | 40 avg | Complete castings, single-cavity mold |
| Cleaning | 60/hr | Gate and riser sawing, trimming and sand blasting (2 men) | 200/hr (avg) | Gate and riser sawing; grinding excess metal (2 men) |
| Scrap | 5% avg | Misruns, cracks, shrinks, etc. | 2% avg | |
| Foundry Metal Loss | 5% | Sawing, grinding, splashings, dross, etc. | 2% avg | |
| Total Cost, (approx) | $0.50/lb or 3.39 x 0.50 = $1.695 ea | | $0.40/lb or 3.01 x 40 = $1.204[a] ea | |

[a] A direct saving of $0.49 each on 1100 castings amortizes the difference in equipment cost of $540.

Source: W. J. Klayer, "Sand Cast and Permanent Mold Aluminum Alloy Parts," *Product Engineering*, Vol. 17, Oct '46, p 81.

**TABLE 2—GRAVITY DIE CASTINGS: FACTORS TO CONSIDER**

| | |
|---|---|
| **COST FACTORS** | |
| Raw Material Costs | Medium cost. Aluminum, copper and magnesium alloys most used; iron and steel sometimes used |
| Tool and Die Costs | Moderate. Less than in die casting, but more than in other methods |
| Optimum Lot Sizes | Large quantities—in the thousands |
| Direct Labor Costs | Medium, compared with sand, plaster mold or precision casting |
| Finishing Costs | Low to moderate, as little machining allowance is necessary |
| Scrap Loss | Low. Most scrap reusable in other castings |
| **PRODUCTION DESIGN FACTORS** | |
| Choice of Materials | Wide (see above) |
| Complexity of Part | Limited. Mold and lack of pressure feeding are controlling factors |
| Maximum Size | Practical limit is under 50 lb (for aluminum) |
| Minimum Size | About 1 oz. Sections as thin as 0.1 in. often cast; 0.060 in. rarely |
| Mechanical Properties | Fair |
| Precision, Tolerances | High; ±0.0015 in. —0.010 in. |
| Surface Smoothness | Good. Often obviates finishing |
| Surface Detail | Fair |
| Getting into Production | Several days to a few weeks |
| Rate of Output | Moderate. Up to 100/hr customary. Sometimes higher |
| General | Gravity die castings fall somewhere between sand castings and die castings as far as complexity, tolerances, cost and production rates are concerned |

Source: "Fabricated Materials and Parts," *Materials & Methods*, Vol. 30, Dec. '49, p 67.

# Design for the process

*What can the process do?* Gravity die castings are dense and fine grained and can be made with better surfaces and to closer tolerances than sand castings (see Fig 1). Tolerances are wider than for pressure die castings and plaster mold castings but higher than for sand and plaster mold casting. Production rates are lower than those obtainable by die casting.

The process therefore stands somewhere between sand and die casting with respect to possible complexity, dimensional accuracy, mold or die costs, direct labor costs and production rates. For many parts it provides an attractive compromise where the ultimate—whether in complexity of one-piece construction, narrow tolerances, or ultra-high production rates—need not be met. Table 1 presents a comparison of costs between sand and gravity die casting. Table 2 is an analysis of cost, production, and design factors related to gravity die casting.

*Design of the mold.* Mold design, as far as the literature on gravity die casting is concerned, is reduced to a set of tolerances (Fig 1) which should be followed in producing the mold cavity. It

is logically, a subject on which few molders care to unburden themselves, since their success in competition depends largely on successful mold design.

General design rules can be stated as follows:

1. Keep section thickness not less than ⅛ in.

2. Use generous fillets to aid metal flow and feeding.

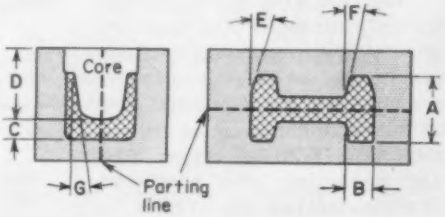
3. Avoid undercuts to eliminate cost-increasing sand cores and collapsible cores.

4. Use a minimum draft angle of 2 deg on inside surfaces and

| | Dimension | Sand Cast[a] | Gravity Die Cast[b] |
|---|---|---|---|
| A | Across Parting Line | ±0.030 in. | ±0.015 in. for 1 in. or less; over 1 in. add 0.002 in./in. |
| B | Between Points Produced by One Part of the Mold | ±0.030 in. | ±0.015 in. for 1 in. or less; over 1 in. add 0.001 in./in. |
| C | Between Points Produced by the Core and the Mold | ±0.030 in. | ±0.015 in. for 1 in. or less; over 1 in. add 0.002 in./in. |
| D | Maximum Length of Core Supported to One End | — | Core diameter x 10 |
| E | Outside Draft | 1° min, 3° desirable | 1° min, 3° desirable |
| F | Draft in Recesses | 2° min, 5° desirable | 2° min, 5° desirable |
| G | Draft on Cores | None | ½° limited, 2° desirable |

[a] W. J. Klayer, "Sand Cast and Permanent Mold Aluminum Alloy Parts," *Product Engineering*, Vol. 17, Oct '46, p 81.
[b] L. F. Swoboda, "Light Metal Permanent Mold Castings," *The Foundry*, Jan. '45, p. 72.

**1** — *Casting tolerances compared for sand and gravity die casting. Refer to the table above.*




***Below: Some aluminum gravity die castings:*** **1** *pole base for street lights,* **2, 3, 4, 5** *housings for various street lights,* **6** *cylinder for closing door mechanism,* **7, 8, 9, 10** *heads for various street lights,* **11** *hand hole cover,* **12** *mounting bracket for street light,* **13** *electric fry pan,* **14** *floodlight bracket,* **15** *slip filter,* **16** *mounting bracket for service station floodlight.*

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3 deg on outside surfaces.

5. Avoid sharp section changes.

6. Know the position of locating points and chucking procedure for gate and riser design.

7. Keep in mind that most surfaces machined on a sand casting are also machined on gravity die castings. However, only 1/16-1/32 in. need be left for machining stock allowance.

8. Specify a minimum diameter of ⅜ in. for cored holes (however, ¼-in. dia holes can be cored).

# Know the casting alloys and their properties

Materials suitable for the gravity die casting process include lead, zinc, aluminum and magnesium alloys, some copper-base alloys, and cast iron. Cast iron is usually cast by the Holley process. Zinc and lead-base castings are usually slush cast, and as a consequence wall thickness is always irregular.

Gray iron gravity die castings account for much less than 1% of total gray iron production, and gravity die cast aluminum alloys account for approximately 40% of total aluminum casting production. Only 5-7% of copper alloy and magnesium alloy production is channeled into the gravity die casting field.

*Gray iron.* Because of its relatively minor use in the gravity die casting process, only limited information is available concerning the properties of gray cast iron. Table 3 shows the different properties to be expected in gravity die cast gray iron castings of varying section size. For small castings, a tolerance of 0.015 in. per in. should be used; the tolerance for large castings is 0.025 in. per in.

*Aluminum.* The low specific gravity of aluminum alloys, relative to copper alloys, requires that gates be made larger for aluminum alloy gravity die cast parts in order to insure proper metal flow. Table 4 compares the properties of several sand cast and gravity die cast aluminum alloys. These follow the usual pattern, with tensile strength of the gravity die cast alloy as much as 36% higher than that of the sand cast alloy. Table 5 shows foundry and other characteristics of some commonly used aluminum alloys. Complete data are not given here because such data are readily available from the major aluminum suppliers.

*Magnesium.* Casting magnesium

**TABLE 3—MECHANICAL PROPERTIES OF GRAY IRON GRAVITY DIE CASTINGS**

| Property | Section Thickness, In. | | | |
|---|---|---|---|---|
| | ½ | ⅜ | 1.2 | 2 |
| Ten Str, 1000 psi | 52 | 34 | 32 | 22 |
| Hardness, Bhn | 197 | 187 | 180 | 170 |
| Compr Str, 1000 psi | 124 | 112 | 119 | 100 |
| Shear Yld Str (torsion), 1000 psi | — | 23 | 19 | 20 |
| Shear Rupture Str (torsion), 1000 psi | — | 44 | 42 | 36 |
| Trans Breaking Load, lb | 606 | 1,665 | 2,670 | 8,200 |
| Trans Defl, in. | 0.178 | 0.166 | 0.238 | 0.240 |
| Mod of Rupture, 1000 psi | 99 | 76 | 71 | 63 |
| Endur Limit, 1000 psi | 32 | 20 | 19.5 | 13.5 |
| Ten Str (after ht tr), 1000 psi | 82 | 50 | 39 | 32 |

Source: E. Hoenicke, "Permanent Mold Gray Iron Castings," *Mechanical Engineering*, Vol. 75, July '53, p 549.

**TABLE 4—MECHANICAL PROPERTIES OF SOME ALUMINUM ALLOYS—SAND CAST VS GRAVITY DIE CAST**

| Alloy ↓ | Sand Cast | | | | Gravity Die Cast | | | | Comparison |
|---|---|---|---|---|---|---|---|---|---|
| | Ult Str, psi | Elong, % | Hard., Bhn | Density (70 F), lb/cu in. | Ult Str, psi | Elong, % | Hard., Bhn | Density (70 F), lb/cu in. | Incr in Ten Str, % |
| 43 | 17,000 | 6 | 40 | 0.096 | 24,000 | 6 | 50 | 0.097 | 26.3 |
| 122 | 37,000 | 1 | 110 | 0.104 | 48,000 | 0.5 | 140 | 0.105 | 29.8 |
| 142 | 37,000 | 0.5 | 105 | 0.100 | 45,000 | 0.5 | 115 | 0.100 | 21.6 |
| 212 | 22,000 | 2 | 65 | 0.103 | 30,000 | 2 | 70 | 0.104 | 36.3 |

Source: W. J. Klayer, "Sand Cast and Permanent Mold Aluminum Alloy Parts," *Product Engineering*, Vol. 17, Oct '46, p 81.

**TABLE 5—PROPERTIES OF SOME ALUMINUM GRAVITY DIE CAST ALLOYS**

| Alloy | Nominal Comp, % | Usually Heat Treated | Foundry Characteristics | | | Typical Applications |
|---|---|---|---|---|---|---|
| | | | Resistance to Hot Cracking | Fluidity | Freedom from Shrinkage | |
| 43 | 5 Si | No | Excellent | Excellent | Good | General purpose alloy. Electric iron sole plates, waffle grids, griddle plates, meter boxes, vacuum cleaner parts |
| 112 | 7 Cu, 1.7 Zn | No | Fairly good | Fairly good | Fair | Good castability and machinability. Vacuum cleaner housings |
| 113 | 7 Cu, 2 Si, 1.7 Zn | No | Fairly good | Good | Fair | Castings with pressure requirements. Washing machine agitators |
| 138 | 10 Cu, 4 Si, 0.3 Mg | No | Good | Good | Fair | Very high hardness in as-cast condition; takes a good polish. Electric iron sole plates |
| B195 | 4.5 Cu, 2.5 Si | Yes | Fair | Fair | Fair | Good casting characteristics, machinability, weldability. Motor housings |
| 356 | 7 Si, 0.3 Mg | Yes | Excellent | Excellent | Excellent | General purpose alloy |

Source: V. Swan, "Aluminum Casting Alloys," *Electrical Manufacturing*, Vol. 52, Aug '53, p 97.

alloys requires extreme caution when removing metal from the furnace. Ladles must be kept at red heat when not in use since the presence of moisture in the melt can cause an explosion.

It is essential to have "hair trigger" dies which work quickly and smoothly. Magnesium alloys are subject to hot shortness; if the gravity die casting remains in the mold an instant too long, cracking may result. The high shrinkage rate of the alloys also requires the immediate removal of the casting from the die. If the casting shrinks around the core, it can be removed from the mold only with difficulty.

Table 6 shows the properties of magnesium-base gravity die alloys.

*Copper.* The high pouring temperatures required for copper-base alloys prevents their being cast under pressure because of the serious reduction in mold life that would result. Aluminum bronze is generally the most popular gravity die cast copper alloy, probably because the alloy group has a very short period of solidification. This alloy group also exhibits no hot shortness, and cracking during solidification is minimized.

Aluminum bronze containing more than 11% aluminum is completely brittle. Addition of iron increases the ductile range of the alloy group to 13% aluminum. In pouring copper-base alloys it is necessary to prevent turbulence and consequent increased oxidation of the molten metal. Excessive oxidation gives rise to cold shuts, folds and seams in the castings.

Table 7 gives the composition and mechanical properties of some typical gravity-die-cast copper-base alloys.

**TABLE 6—MECHANICAL PROPERTIES OF GRAVITY DIE CAST MAGNESIUM ALLOYS**

| Alloy | Ten Str, 1000 psi | Yld Str, 1000 psi | Elong. (in 2 in.), % | Hardness, Bhn | Shear Str, 1000 psi | Fatigue Str ($10^8$ cycles), 1000 psi |
|---|---|---|---|---|---|---|
| AZ63A[a] | 29, 40 | 14, 19 | 6, 5 | 50, 73 | 16, 19 | 9-12, 11-15 |
| AZ81A[b] | 40 | 12 | 15 | 55 | 17 | 11-14 |
| AZ91C[c] | 24, 40 | 14, 19 | 2, 5 | 52, 66 | 16, 19 | 11-14, 10-13 |
| AZ92A[a] | 24, 40 | 14, 21 | 2, 2 | 65, 84 | 16, 20 | 12-14, 11-15 |
| AM100A[a] | 22, 40 | 12, 16 | 2, 4 | — | — | — |
| ZE41A-T5[c] | 30 | 20 | 3.5 | 62 | 22 | — |
| ZK51A-T5[c] | 40 | 24 | 8 | 65 | 22 | 8-10 |
| ZH62A-T5[c] | 40 | 25 | 6 | 62 | 23 | — |

[a]First number is property as-cast, second as soln treated and aged. [b]Solution treated only. [c]Solution treated and aged at 350 F.
Source: Dow Chemical Co.

**TABLE 7—COMPOSITION AND PROPERTIES OF GRAVITY DIE CASTINGS OF COPPER-BASE ALLOYS**

| Typical Composition, % | | | | | Yield Point, psi | Tensile Strength, psi | Elongation (in 2 in.), % | Hardness, Bhn |
|---|---|---|---|---|---|---|---|---|
| Cu | Al | Fe | Mn | Ni | | | | |
| 89 | 10 | — | 1 | — | 32,000 | 78,000 | 25 | — |
| 89 | 9 | — | 2 | — | 28,400 | 66,400 | 30 | — |
| 88 | 9 | 3 | — | — | 31,000 | 76,000 | 40 | 135 |
| 85 | 10 | — | — | 5 | 49,600 | 72,400 | 2 | 185 |
| 84 | 10 | 3 | 3 | — | 28,400 | 88,200 | 11 | 159 |
| 79 | 9 | 6 | — | 6 | 36,400 | 78,400 | 15 | — |
| 77 | 10 | 3 | 5 | 5 | 88,000 | 100,200 | 1 | — |

Source: S. E. Gregory, et al. "Permanent Mold Casting of Copper-Base Alloys," *Machinery* (N.Y.), Vol. 56, June '50, p 155; and J. L. Erickson, "Permanent Mold Casting of Copper-Base Alloys," *Iron Age*, Vol. 162 (Part 1), July 22, '48, p 85.

# Evaluate materials and coatings for the dies

*Die materials.* Almost all dies used in gravity die casting are made from metal. Table 8 lists steels in common use as die materials.

The "Parlanti" process, developed in England during World War II, uses an aluminum die which is cast in sand. After casting, the die is cleaned up and its surface anodized. Gray iron and aluminum bronze have been successfully cast by this process, since the high thermal conductivity of the aluminum protects the die from the high service temperatures. With this process it is possible to make castings that have high mechanical properties and good pressure tightness.

Since the production of the metal die entails an expense which some users are not willing to absorb on relatively low production items (e.g., 200-500 castings), some applications make use of ceramic materials for the gravity dies. The dies use a high grade refractory filler and binder. The binder bonds the filler with sufficient green strength and, after

**TABLE 8—APPROXIMATE CHEMICAL COMPOSITIONS OF STEELS FOR GRAVITY DIE MOLDS[a] (%)**

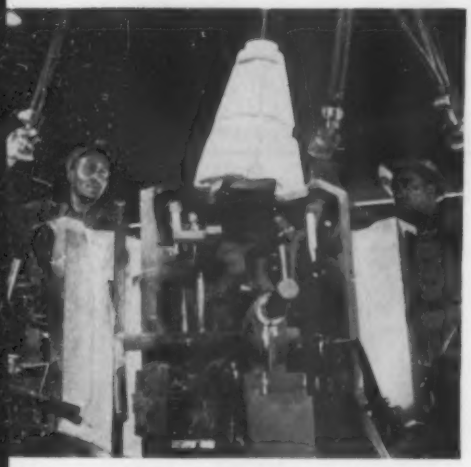
| Steel | AISI Type | C | Mn | Si | Cr | V | W | Mo | Al | Ni |
|---|---|---|---|---|---|---|---|---|---|---|
| Chromium-Vanadium | L2 | 0.50 | 0.60 | 0.25 | 1.00 | 0.20 | — | — | — | — |
| Chromium-Molybdenum | H12 | 0.35 | 0.30 | 1.00 | 5.00 | 0.40 opt | 1.25 opt | 1.50 | — | — |
| 9% Tungsten | H20 | 0.30 | 0.25 | 0.25 | 3.50 | 0.50 opt | 9.00 | — | — | — |
| Medium Carbon | L6 | 0.70 | 0.70 | 0.20 | 0.80 | 0.10 opt | — | 0.30 | — | 1.60 |
| Nitralloy G | | 0.30 | 0.50 | 0.25 | 1.20 | — | — | 0.50 | 1.10 | — |

[a]Although not referred to by specific composition, various grades of Meehanite are also used as materials for gravity die molds.
Source: "The Composition and Heat Treatment of Die Casting Dies and Permanent Molds," *Metals Handbook*, ASM, 1948, p 674.

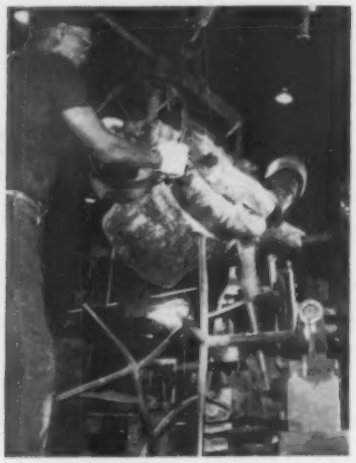
## Bendix Pours a Semi-Permanent Gravity Die Casting

**and eliminates 40% of the machining required on a sand casting**

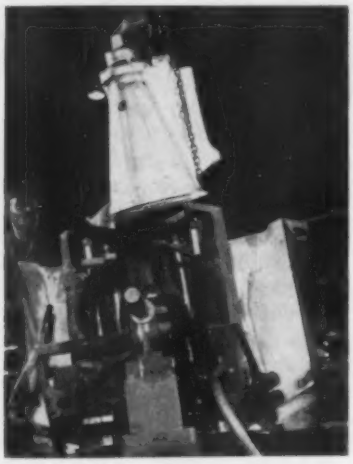
Photos Eclipse-Pioneer Div., Bendix Aviation Corp.



***Sand core with 14 chills** is lowered into four-part mold manually operated with rack and pinions.*



***356 aluminum alloy** casting weighing 60 lb is poured. Production rate: five pieces per hour.*

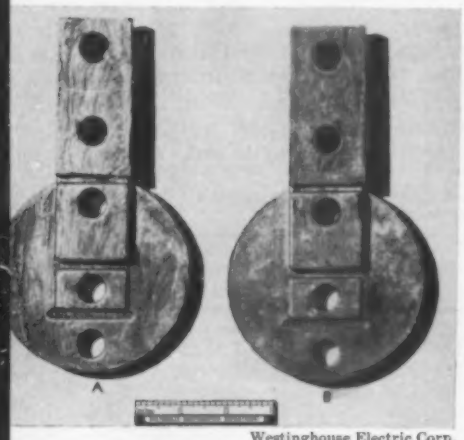


***Casting is removed** from the mold. Cored holes near top of casting were produced with core pins.*

baking at 1300 F, forms a silica bond.

The use of ceramic gravity dies has several limitations: 1) gray iron cannot be cast by the process, 2) deep flanges set some distance apart are difficult to remove from the die, and 3) small cored sections and unsupported corners also offer some difficulties.

Up to 400 castings have been produced in aluminum alloys when ceramic dies were carefully handled. When castings are required in alloys of low heat capacity, or in alloys prone to undesirable structural changes when rapidly cooled, ceramic die materials of low thermal conductivity are essential.



Westinghouse Electric Corp.

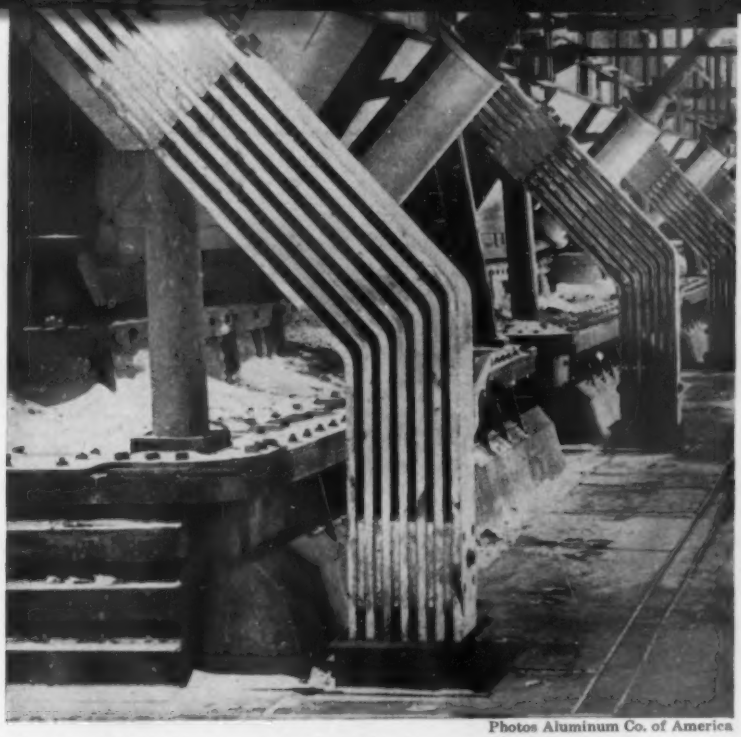
**2**—*Proper mold wash eliminated cold shuts on casting at right.*

*Die coatings.* The functions of a die coating are to: 1) act as an insulating barrier between the die cavity and the molten metal, 2) serve as a lubricant for the moving parts of the die, 3) promote better surface appearance, 4) prevent the casting from sticking to the die, and 5) decrease the buildup of oxide on the die cavity. The difference between one die coating and another may spell the difference between an acceptable casting and a rejectable casting. Fig 2 illustrates this point. In one case the die was coated with a mixture of whiting, water glass, and water. The casting with the flaw-free surface was coated with a mixture of distilled water, titanium dioxide, colloidal graphite and water glass.

A few of the many types of die coatings which are currently used in gravity die casting are as follows:

1. One part by volume of concentrated graphite of the powdered type, plus ten parts of distilled water.
2. One part by volume of concentrated graphite powder, plus ten parts of distilled water, plus 6% by volume of the highest density sodium silicate (water glass).
3. One part by volume of concentrated graphite powder, plus ten parts of distilled water, plus 6% by weight of borax.
4. One pint of colloidal graphite, plus twenty gallons of distilled water.
5. Light mineral oil plus graphite mixed to a thin consistency.
6. Tallow plus graphite. This combination is kept liquid by heating and is applied with a brush.
7. Beeswax plus graphite (heated and applied with a brush).
8. Aquadag (a proprietary suspension of colloidal graphite in water).

These coatings can be applied to the die during the production run. The die is generally heated before the first casting is poured in order to reduce the initial thermal shock and to provide a more satisfactory base for the application of the die coating. Once the coating is applied, the operator can observe the casting surface to determine the need for additional applications.



Photos Aluminum Co. of America

***Bus bar** of EC aluminum is used on aluminum pot line.*

**TABLE 1—TYPICAL TENSILE PROPERTIES OF EC ALUMINUM**

| Alloy and Temper | Approx Cold Red., % | Ten Str, psi | Yld Str (0.2% offset), psi | Elong (in 10 in.), % |
|---|---|---|---|---|
| EC-O | 0 | 12,000 | 4,000 | 23 |
| EC-H12 | 18 | 15,000 | 12,000 | — |
| EC-H13 | 28 | 17,000 | 16,000 | — |
| EC-H14 | 38 | 16,000 | 14,000 | — |
| EC-H16 | 57 | 18,000 | 16,000 | — |
| EC-H17 | 66 | 20,000 | 19,000 | — |
| EC-H19 | 96 | 27,000 | 24,000 | 1.5 |

**TABLE 2—EFFECT OF TEMPERATURE ON FATIGUE OF EC ALUMINUM**

| Temp, F | Fatigue Limit, psi[a] | |
|---|---|---|
| | EC-O (annealed) | EC-H17 (strain hard. 66%) |
| 81 | 4000 | 6000 |
| 212 | 3900 | 4800 |
| 356 | 3100+ | 3500 |

[a] After 100 million cycles.

# EC Aluminum—

## Its Properties at Elevated Temperatures

*Here are the fatigue, tensile and creep data you need to use this high-conductivity metal in wire, cable, bus bars, coils and other electrical parts*

**by C. L. Carlson,** *Materials Engineering Dept., Westinghouse Electric Corp.*

■ Until the introduction several years ago of high strength aluminum alloy bus bar, EC grade aluminum was widely used in many low voltage applications. However, the elevated temperature data needed for wider application were not available. The elevated temperature test results presented here will enable the designer and engineer to better appraise the value of EC aluminum for expanded applications.

Although there will be some spread in results for different lots of material, the short-time tensile properties can be considered adequate for use in the mechanical design of electrical conductors for short-time loading. Similarly, the fatigue and creep properties discussed are adequate for use in designing EC aluminum conductors for service involving prolonged loading.

Data are given for annealed as well as cold worked material. The cold reductions performed were 11, 20, 28, 35 and 41%. In addition, EC-H17 was used in the fatigue and creep tests. In terms of commercial tempers, the annealed material is designated EC-O and the various cold worked tempers such as EC-H12, EC-H13, EC-H14, and EC-H17 are roughly equivalent to 18, 28, 38 and 66% cold reductions, respectively. Typical tensile properties for these as well as other available tempers are shown in Table 1.

### Conductivity

Electrical conductivity does not change with cold work, at least up to 41% cold reduction—the maximum tested in this program.

### Tensile and yield strength

As temperature increases, there is a marked reduction both in ultimate and yield strength of EC grade aluminum (see Fig 1). Strength increases with cold reduction up to 392 F. Specimens tested at 572 F, however, show complete annealing in material having a minimum cold reduction of 30-35%, even during the short

time the specimens were held at the testing temperature. All cold worked material annealed completely when tested at 752 F.

**Fatigue strength**

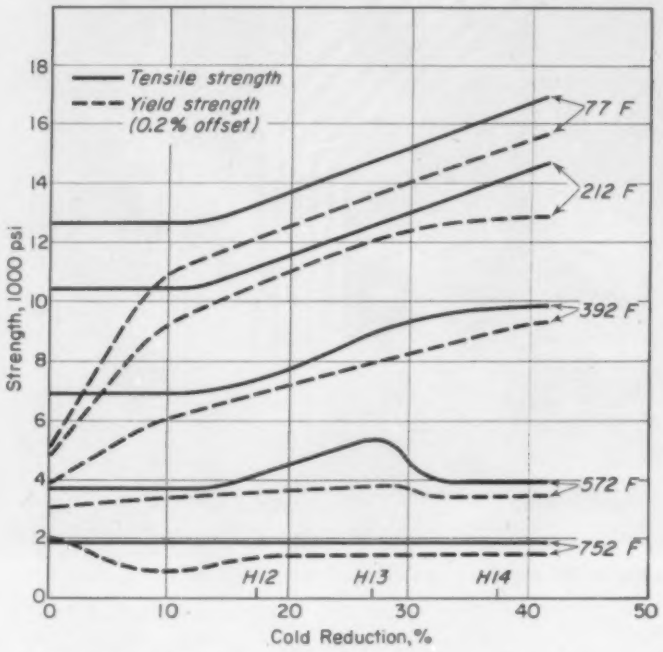
Table 2 shows the effect of temperature on fatigue strength. From the data, it is apparent that annealed material undergoes only a moderate decrease in fatigue strength as temperature increases. The strain-hardened material (EC-H17) suffers more extensive degradation of properties with temperature.

Not enough data were determined to present a reliable curve showing the effect of cold reduction on the fatigue strength of EC aluminum. Fatigue data are available, however, for 99.60 and 99.0% minimum aluminum in several tempers. Since EC aluminum lies between these materials in minimum and typical aluminum contents, it can be assumed that the fatigue curves for EC aluminum will be similar to those shown in Fig 2.

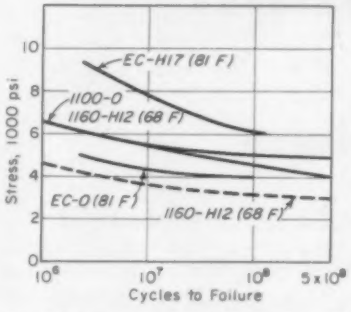
**Creep strength**

At room temperature, hard drawn EC wire normally has a relatively low creep rate. Fig 3 shows the load-temperature relationship required to produce specific amounts of creep in 100 hr. The curves show that lower loads and less time are required to deform the metal as temperature increases.

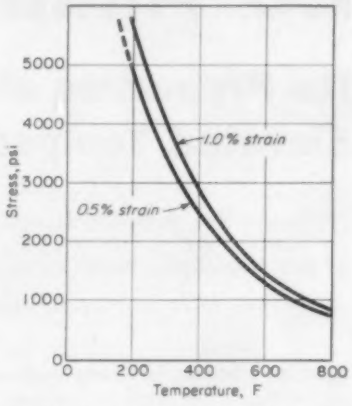
At all test temperatures except 752 F, it was found that the yield strength of the EC aluminum was approximately double the creep strength. This relationship emphasizes the need for caution in applying EC aluminum at loads that approach 50% of the yield strength at operating temperature.




**1**—*Strength of EC aluminum vs percent cold reduction.*




**2**—*Fatigue curves for 99% min aluminum in several tempers.*

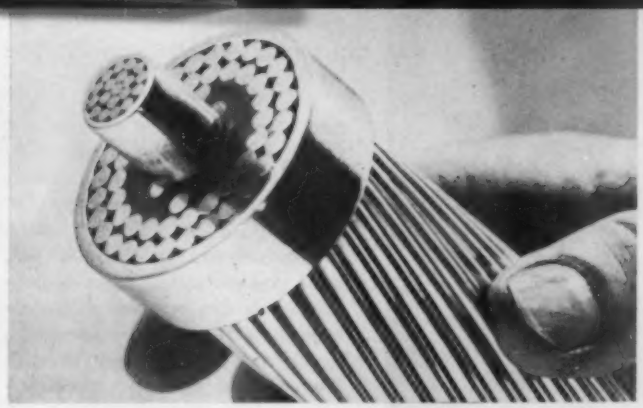



**3**—*Load-temperature required for creep in 100 hr.*

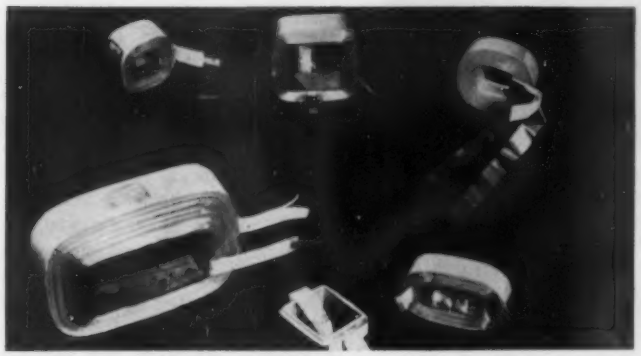
# When to use EC aluminum

EC aluminum has a minimum aluminum content of 99.45% and a guaranteed electrical conductivity of 62% of the international annealed copper standard (IACS). In comparison, the commercial grade has a minimum aluminum content of 99% and does not guarantee minimum conductivity.

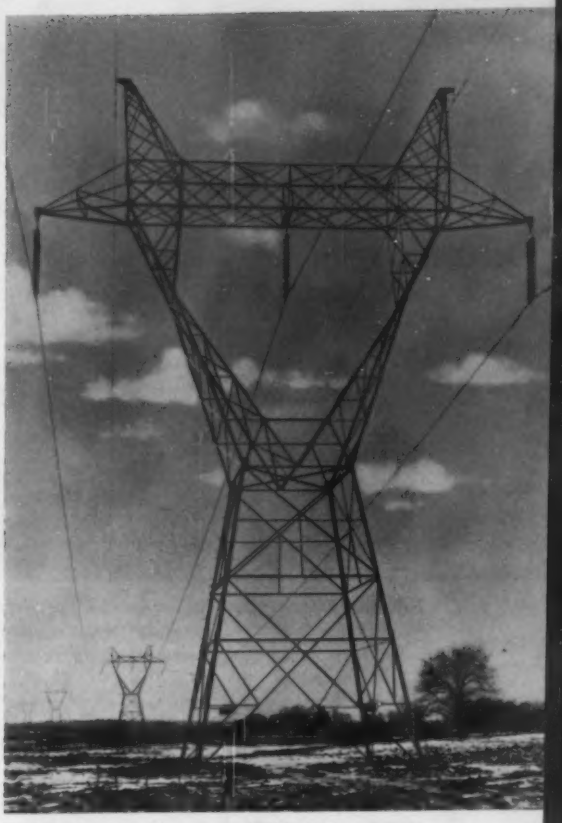
For the last 65 years, aluminum wire of about 60% conductivity has been used extensively in Great Britain and elsewhere in Europe. The widespread use of aluminum for conductor applications in the United States has developed relatively recently—since the introduction of the EC grade. Both here and abroad, the composite steel-cored stranded aluminum



***Expanded*** *ACSR cable is 1.6 in. in dia, has 42,000 psi ultimate tensile strength. It is produced by placing a two-layer filler of twisted and treated paper between steel core and aluminum outer strands.*



***Strip wound coils*** *for transformers, solenoids, lifting magnets, and small motors. Coils can be wound for largest power units.*



***Transmission*** *line uses ACSR wire.*

conductor wire (ACSR) has been used with outstanding success ever since its introduction in 1910. The aluminum wire in ACSR is now made from EC aluminum.

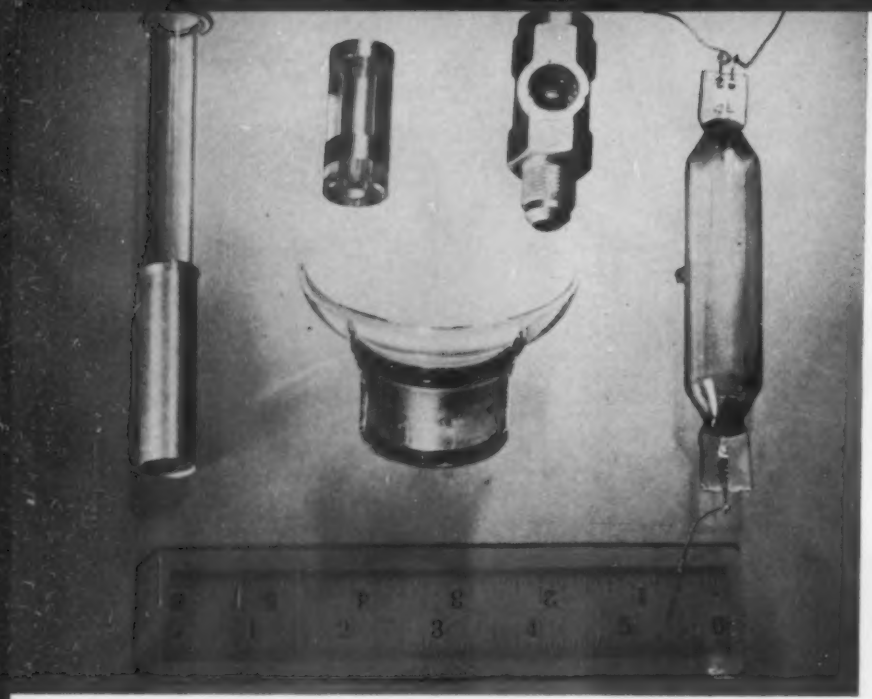
In addition to serving the electrical industry ever since electric power transmission over appreciable distances was inaugurated, EC aluminum has been used in aluminum reduction plants to carry the power needed for production of the light metal. Large EC aluminum bus installations in these plants have the advantage over copper of greater corrosion resistance in the atmosphere of the pot line. One major supplier uses continuously cast EC bus bar for his reduction plants while others use extruded bar.

Since the inception of the test program whose results are presented here, most low voltage switchgear bus bars have been made of the high strength aluminum alloy which was introduced as a replacement for EC bar. The high strength alloy offers increased strength with only a small decrease in electrical conductivity. However, many other actual and potential applications remain for EC aluminum (see box).

## *Here's How EC Aluminum Is Being Used*

- Primary and secondary transmission line cables
  - Bare aluminum conductor, steel reinforced (ACSR)
  - Bare all-aluminum (stranded)
- Power cables
- Building wire
- Service drop wire*
- Household electric wire*
- Telephone wire*
- Aircraft conductor wire*
- Switchboard model bus bar
- Lightning rods*
- Grounding cables*
- Ground rods*
- Forged bushing flanges
- Shielding cans
- Capacitor cans
- Capacitor cases
- Capacitor foil conductor
- Large bus-to-d.c. converter
- Pot room feeder bus
- Tubular bus for switching stations
- Channel conductors
- Battery ground cable
- Reactor coils
- Transformer windings (all sizes and types, including aluminum wire and aluminum foil or sheet strip conductors)*
- Magnet wire
  - Starter motors
  - Starter motor controls
  - Ignition equipment
  - Coils
  - Solenoids
  - Magnetos
  - Ignition harnesses
  - Distributors
  - Induction motors
- Station bus bars
- Meter disks
- Die cast rotor conductors

*These applications have not realized their full potential at this time.



***Variety of seals** are shown here: Upper left to right are 1) solder glass used to join aluminum to glass tubing, 2) glass metallized with thin layers of silver, 3) compression seal showing a glass window in a bronze bushing, 4) Housekeeper seal with thin (0.0005 in.) molybdenum foil sealed to glass of quartz mercury arc lamp. Lower center is a section of a Housekeeper seal between copper and glass.*

# Five Ways to Seal Glass to Metal

- *Where to use each method*
- *What materials to use*
- *Comparative data on thermal expansion*

**by W. A. Gleason,** *Product Engineer, Corning Glass Works*

■ All five of the basic methods of sealing glass to metal require that:

1. The glass should wet and adhere to the metal when both materials are at the working temperature of the glass.
2. The metal should have no sharp changes in expansion between the glass's setting temperature and the lowest temperature to be encountered in service.
3. When heated, the glass should not reboil nor the metal emit gases.

In general, matched seals or solder sealing glasses should be used when glasses and metals of closely matching thermal expansion characteristics are to be sealed. Graded seals, Housekeeper seals and metallized glass can be used when metals and glasses of different expansion characteristics are to be sealed.

*Metal preparation* — Oxidizing the metal surface prior to sealing provides two advantages. It removes carbonaceous matter and frees occluded gases, eliminating fine bubbles along the metal interface. And the oxide coating dissolves and diffuses into the glass, improving the bond. The best seals are obtained when only a thin oxide film remains at the interface after the seal is complete. Thick oxide films tend to scale from the metal.

### 1. Matched seals

**should be used where the metal and glass to be sealed have closely matched expansion characteristics. Where slightly different expansions exist a compression seal may be feasible.**

Although a zero expansion differential provides a completely unstressed seal, some differential is permissible. Fig 1 shows thermal expansion curves for several common sealing glasses and metals. The circles on the glass curves denote the normal setting points of the glasses. The dimensional difference between a sealed glass and metal at room temperature is determined from the vertical distance between the setting point of the glass and the expansion curve of the metal.

In general, a differential elongation of less than $1 \times 10^{-4}$ results in excellent stress conditions. A differential of $1$ to $5 \times 10^{-4}$ results in stress conditions satisfactory for most medium sized seals. Differentials of $5$ to $10 \times 10^{-4}$ result in critical stress conditions.

A poor match between glass and metal is commonly overcome by designing a compression seal. Because glass fails only in tension, it can withstand high compressive stresses. In compression seals a ring of high expansion metal surrounds the glass; when the seal cools, the glass is under compressive stress.

The accompanying table lists various sealing metals and matching glasses. Because chemical composition is not an adequate guide to sealing characteristics the glasses are identified by Corning code numbers. Other glass producers have sealing glasses

available corresponding to some of those shown in the table. Sealing conditions should be detailed to the glass producer.

## 2. Solder glasses

**should be used for sealing components in equipment which cannot be exposed to the high sealing temperatures commonly used for making other types of seals. Expansion characteristics must usually be matched.**

Solder sealing glasses are usually in the form of powder suspended in a volatile liquid. When organic binders such as nitrocellulose are added, firing must be carefully controlled to make sure the binder is burned out.

Setting points of solder glasses are usually about 600-700 F. This temperature range is well below the annealing temperature for most glasses; thus seals can be made with little effect on the glass being joined. Soldering glasses should be selected to have expansion characteristics closely matching those of both the metal and glass being joined.

Although chemical durability of solder glasses is generally lower than that of other glasses, it is adequate for most applications. Electrical characteristics are satisfactory.

Recently developed low-melting solder glasses look promising for use in semiconductor diodes and transistors. Melting points may be as low as 212 F. These modified arsenic sulfide glasses have resistivities of about $10^{12}$-$10^{16}$ ohm-cm at room temperature and dielectric constants of about 12. They have relatively high thermal expansion coefficients; values range from about 140 x $10^{-7}$ to as high as 330 x $10^{-7}$ per °F for the lower melting types.

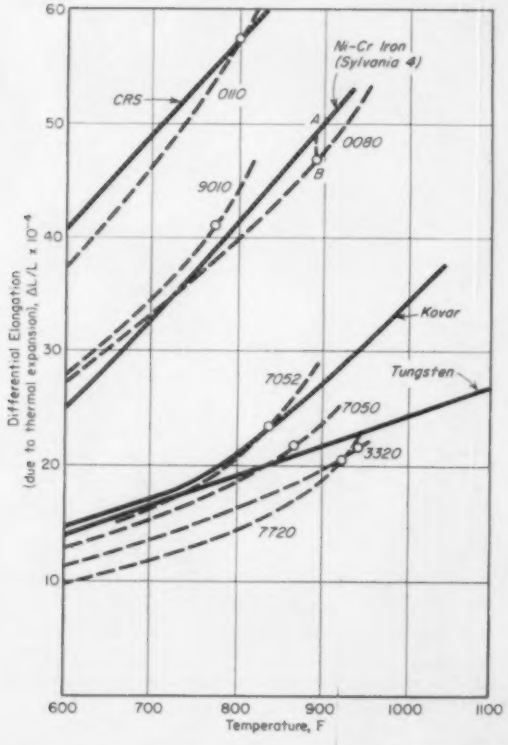
## 3. Graded seals

**should be used for sealing glasses and metals having substantially different expansion characteristics.**

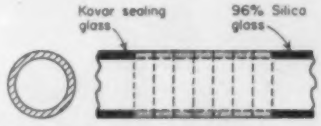
Graded seals consist of several intermediate glasses differing successively in their expansion characteristics. When a metal and glass are joined by such a seal, the total difference in expansions between the glass and the metal is bridged by glasses differing only slightly in expansion characteristics.

Fig 2 shows a graded seal made of powdered glasses pressed in layers, each of which has a different expansivity, and fired to form a composite glass tube.

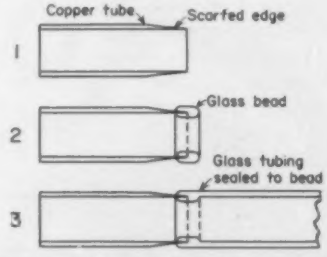
Another special type of graded seal is made by adding carefully measured amounts of oxides to 96% silica glass tubing at the stage in manufacture when the glass is porous, just after acid leaching. After subsequent firing, the tube has an expansion gradient corresponding to the degree of oxide concentration in the glass. Obtainable expansion range is such that tubes can be used to seal silica glass to low-expansion borosilicate glasses.




**1**—*Differential elongations caused by thermal expansion characteristics of four metals (solid curves) and seven glasses. Circles on dashed curves indicate setting points of glasses. Expansion differentials and resulting dimensional differences at room temperature are equal to the difference between the two curves measured at the setting point of the glass, e.g., distance AB.*




**2**—*Typical graded seal construction shows sections of glasses of slightly different expansion characteristics forming a bridge between Kovar sealing glass and 96% silica glass.*




**3**—*Procedure for making Housekeeper seal between copper and glass tubing.*

### 4. Housekeeper seals

**should be used for joining glasses to relatively soft metals in thin sections. Expansion characteristics need not be similar.**

Probably the most widely used metal in Housekeeper seals is copper. The metal must be soft enough and thin enough so that it can plastically deform to conform to dimensional changes taking place in the glass as it cools. Where the metal to be joined is in relatively heavy sections, as in copper tubing, seals can be made by scarfing the metal in the area to be joined. Fig 3 shows this technique used for sealing a copper tube to a glass tube.

Another form of Housekeeper seal, used for lead-in connections of lamps and electron tubes, can be made with metal foil. A strip of foil is passed though a short glass tube. The tube is then heated and pressed flat on the foil, forming the seal. Molybdenum strips less than 1 mil thick can be joined by this technique to silica glass or 96% silica glass with no difficulty.

### 5. Metallized seals

**should be used for joining metals and glasses of widely different expansion characteristics, and where assembly by simple metal soldering is advantageous.**

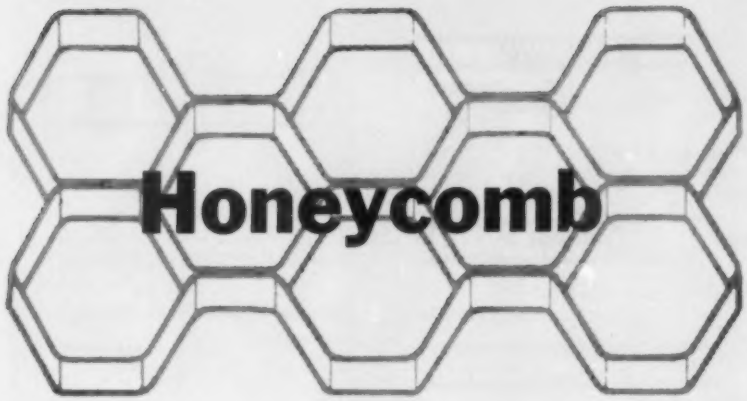
Actually, the principle of sealing by first metallizing the glass surface is the same as that used for Housekeeper seals, i.e., the metal in direct contact with the glass is thin enough to deform plastically with dimensional changes in the glass.

Usually a silver or platinum compound, in the form of a paste, is fired on the glass surface. The metal diffuses into the glass during firing, providing a strong bond. Resulting surface films are commonly plated with copper to provide a good surface to which to solder. Total metal thickness (including plate) should not exceed 1 or 2 mils. Metals can then be soldered to the coating by conventional soldering techniques. Resulting bonds are comparable in strength to matching seals.

**GUIDE TO GLASSES AND METALS FOR MATCHING SEALS[a]**

| Metal or Alloy | Tradename or Type | Matching Glass (Corning Code)[b] | Comments |
|---|---|---|---|
| CRS, SAE 1010, AISI C1010 | Other grades of soft steel or iron also used | 1990, 0110 | Often plated with Cu, Cr or Ag to prevent excessive oxidation. External rings of iron frequently used with Pt-sealing glasses to form compressive seal |
| 17% Chromium Iron, AISI 430A | Allegheny Telemet | 9019 | One use: funnel in colored TV tubes |
| 28% Chromium Iron | Allegheny Sealmet-1, Ascaloy 446, Carpenter 27 | 9012, 8871, 9015 | Used for TV tubes; iron should be preoxidized in wet hydrogen gas |
| Platinum | — | 0120, 0080, 0010, 7570, 9010, 8160 | Mostly used for scientific apparatus; unnecessary to preoxidize platinum |
| Composite: Core 42% Ni, 58% Fe; Sheath Cu | Dumet | | Widely used sealing metal, e.g., most radio tubes and lights use Dumet leads. Surface usually coated with borax to reduce oxidation. Radial expansion: 50 x $10^{-7}$ per °F; axial expansion: 35 x $10^{-7}$ per °F. Wire size usually limited to 0.020 in dia |
| Nickel-Chromium Iron (42% Ni, 6% Cr, 52% Fe) | Sylvania No 4, Allegheny Sealmet HC-4, Carpenter 426, Driver Harris 152 | | Relatively large seals can be made. Alloys should be preoxidized in wet hydrogen atmosphere |
| Nickel-Cobalt Iron (28% Ni, 18% Co, 53% Fe) | Kovar, Fernico, Rodar, Therlo | 7052, 7050, 7055, 8830, 7056, 7040, 8831 | Kovar and Therlo have the lowest expansion. Kovar and Fernico should be annealed after cold working and pretreated in a hydrogen atmosphere furnace prior to sealing |
| Molybdenum | — | 7052, 1723, 7055, 1720, 7056, 8830, 7050, 7040 | Surfaces should be cleaned in fused nitrite and not over-oxidized; a patented process is available to protect Mo from oxidation by forming a molybdenum disilicide coating |
| Tungsten | — | 7720, 7750, 3320 | Should be cleaned and not over-oxidized. 7720 is most commonly used glass; softer 3320 is slightly better match (see Fig 1) |
| Copper | OFHC Grade | 7295 | High expansion makes metal difficult to seal; controlled atmosphere (10% hydrogen, 90% nitrogen) oven should be used to control cooling after fusion |

[a] All glasses shown are available in powder form for compacting and sintering (Multiform) except: 0080, 1720, 1723, 3320, 7040, 7720.
[b] Composition is not sufficient indicator of sealing characteristics; other glass producers have sealing glasses similar to some shown here.
[c] Alloy 152 is actually a nickel iron.



# Honeycomb

*Part 2*

- **How to Fasten Honeycomb Sandwich**
- **Nonstructural Uses of Honeycomb**

**by Peter J. B. Stevens and Lloyd M. Polentz**
*Engineering Consultants, Los Angeles*

*Last month the authors told how to design honeycomb sandwich and what materials can be used. This month they tell how to build up panels and assemblies. Also: new uses where loading is not a major factor.*

## Fastening honeycomb components

**Joining core to core**

When stress conditions are expected to vary across the face of a finished sandwich panel, different arrangements or alignments of the core material, or combinations of different cell sizes, can be used in the sandwich. Since the core has a greater stiffness in the *L* direction, variations in stress can be accommodated by changing the alignment of the *L* direction of the core throughout the panel. In such a case, the core is divided into separate pieces which are usually joined together before the skins are attached.

By making the cell size smaller or the cell wall thicker in a particular area of the sandwich panel, the density of the core (and therefore the weight of the panel) can be increased, raising shear and compressive strengths in that area.

Thus, joining two or more smaller pieces of core to form one large piece is a technique often used when it is physically or economically impossible to form panels by any other method, when it is necessary to vary the core size or the alignment of the L direction, or when the size of core materials required for a certain design is not readily obtainable.

*Joint types*—Butt joints are the most common means of interconnecting two pieces of honeycomb core. When two core pieces are joined in this manner they are bonded together along the butt with an adhesive. Extensive analysis has proved that there is no loss of structural strength in such joints. In some instances the design can specify that the bonding agent is to fill the cells adjacent to and on both sides of the joint itself. This form of jointed core is actually stronger than a continuous piece of unjointed core, since the area between the two pieces is considerably densified.

Another splice commonly used is a zig-zag type of butt joint. In this case, the mating edges are cut in such a way that they have the appearance of having been cut with pinking shears. The mating pieces are butted and bonded together.

Interlocking of the core cells is another, optional, joint design which provides a stronger connection than the butt joint. This type of joint is formed by forcing together two overlapping core edges so that cells of the two pieces actually cut into one another. The cuts are straight and clean, and no compressive strength is lost. After interlocking, the cores are bonded with adhesive. Interlocking of this sort is generally used on plastics and paper honeycomb cores, although variations of this technique are also used on aluminum honeycomb.

**Joining core to facing**

Core-to-facing bonds must withstand almost the same amount of shear stress as the core. High peel strength, which is dependent primarily on the adhesive, is desirable in structural sandwiches. Although high peel strength is not usually a determining factor in panel design, it does improve impact characteristics and helps the panel resist failure caused by highly localized loads. High shear strength, however, is a prime requisite of a core-to-facing adhesive bond.

From a design standpoint, sandwich bond strengths are influenced primarily by the type of bonding material and the cell core size. For the finished panel to have its designed strength, it is necessary that the adhesive be uniformly distributed between the facing and the core. Where

panels are designed for structural applications, therefore, it is advisable to specify that the adhesive be applied as a supported film on a carrier cloth. When an adhesive carrier cloth is used in the fabrication of a panel, peel strength is higher.

*The adhesives*—Several distinct types of adhesives have been developed for use in the fabrication of honeycomb sandwiches. Different formulations of the same general type of adhesive may have widely different strength properties. The three major types of adhesives for core-to-facing bonds are:

1. Combinations of thermosetting resin and elastomeric polymer. Phenol-formaldehyde resins modified by vinyl polymers, rubber, or nylon are representative of this class. These adhesives may be in the form of liquid solutions or supported films.

2. Epoxy resins. These are normally paste-type adhesives, formulated without solvents.

3. Epoxy-phenolic systems. These have been developed especially for high temperature service. Fillers and carriers are used, and use of solvents is generally avoided. This type of adhesive is usually supplied in the form of a supported film.

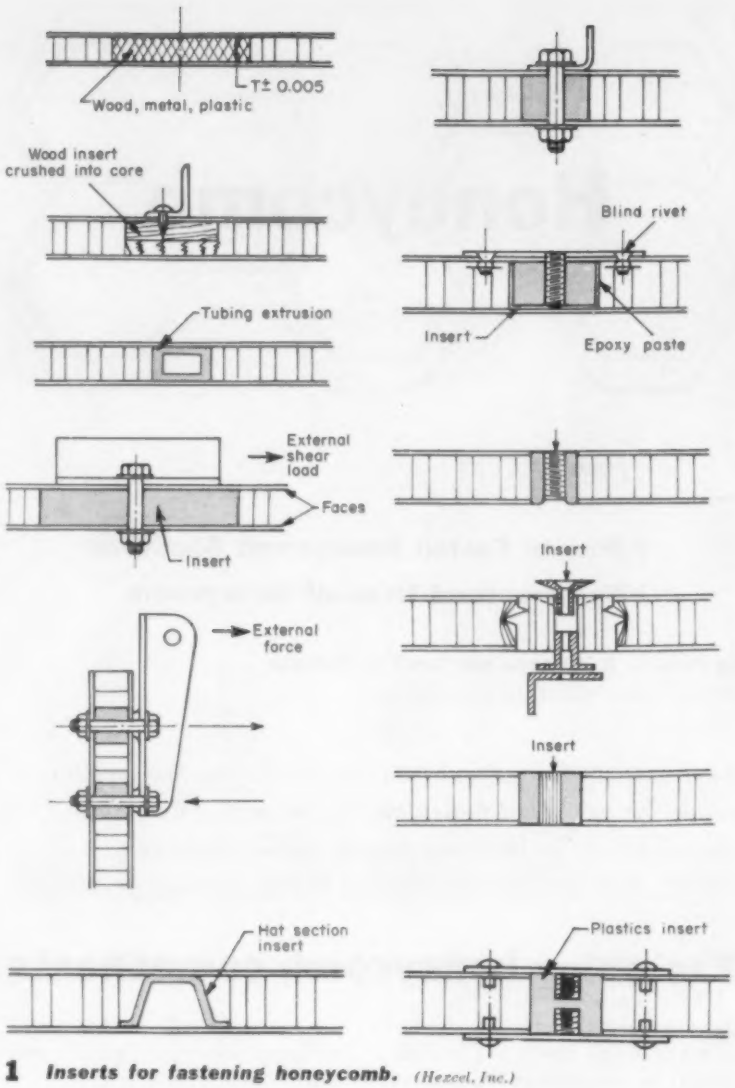
(Editor's note: Assemblying honeycomb structure by brazing was recently discussed in M/DE, Mar '59, p 100.)

**Joining panels**

Honeycomb sandwich construction is a potential replacement for any application where sheet and stiffener panels are presently used. However, whenever honeycomb sandwiches are used to replace other types of panels, certain fundamental principles must be observed with regard to edge close-outs and fasteners.

The best fastening design for any panel is one that has the fastening load evenly distributed across a broad area. In the case of honeycomb panels this design consideration becomes imperative.

Generally honeycomb sandwiches cannot withstand, without help, the compressive loads caused by bolts, rivets, screws and other mechanical fasteners. To solve this problem, a great number of inserts and special fasteners have been devised, many of which are shown in Fig 1.



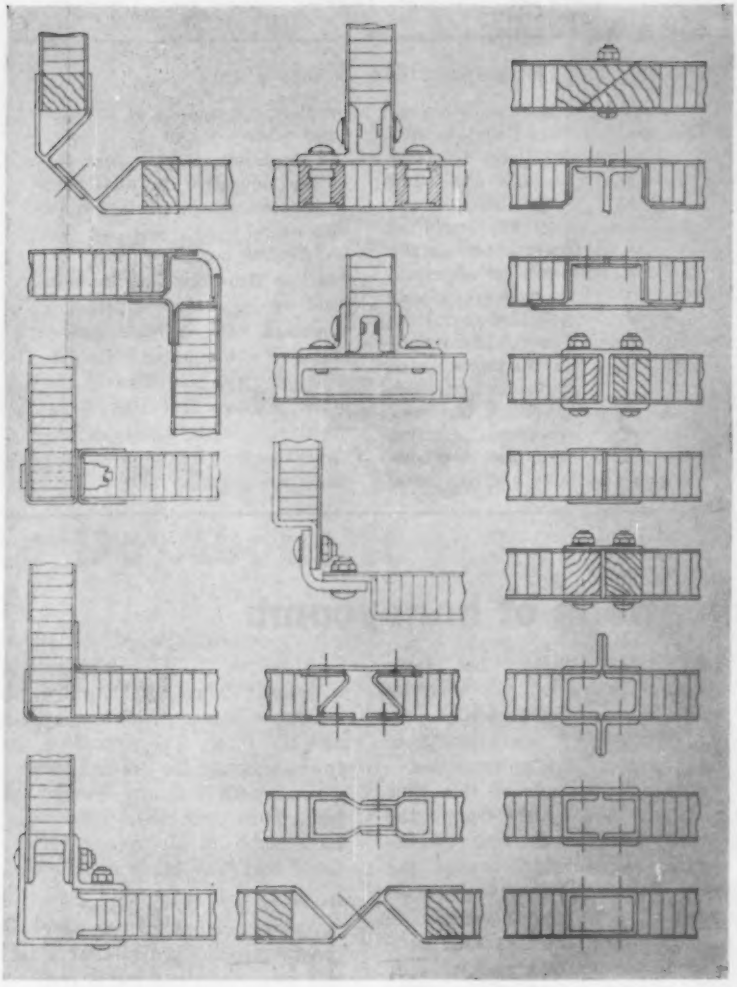

**1** ***Inserts for fastening honeycomb.*** *(Hexcel, Inc.)*

Even though the broad design objectives for close-outs and fasteners—ease of fabrication, proper transmittal of shear loads, and resistance to edge peel—are agreed on, there are no standardized designs. Each finished structure is primarily the result of the designer's own engineering knowledge and ingenuity.

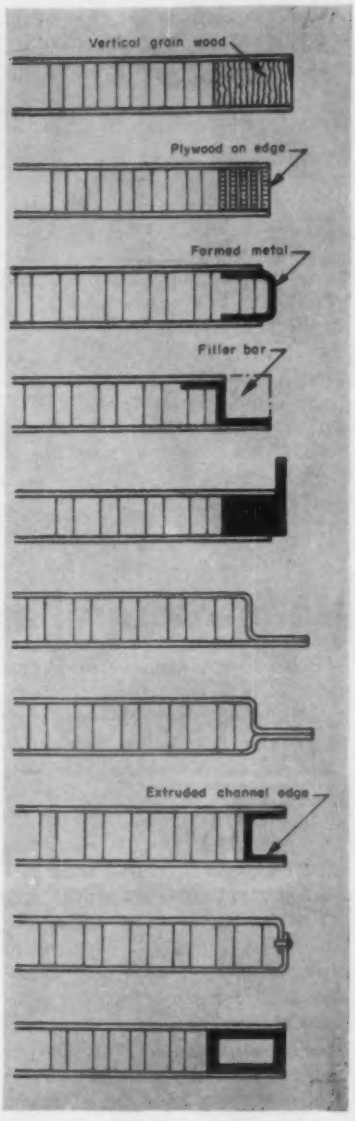
In general, fastening technique is based upon strengthening the core through the use of one or more of the following:

1. Wood, plastics or metal strips. These strips, bonded between the facing sheets, are installed—prior to curing the adhesive—at the time the panel is fabricated. The fastener is subsequently attached directly to the strip. Compressive loads and fasteners can then be applied to the facings immediately over the strip without damage to facings or core.

2. Molded-in plastics blocks. The block material is installed after the panel is fabricated. A hole is drilled in one facing, and



**2 Honeycomb joint possibilities.** *(Douglas Aircraft, Inc.)*




**3 Honeycomb and closures.** *(Hexcel, Inc.)*

a portion of the core is removed. This area is then filled with an epoxy resin filler into which the fastener is directly inserted. The molded-in blocks harden in place to give a solid foundation to the fasteners, which can be tightened with no harmful effect to the core facing sheets.

3. Aluminum spacer inserts. A hole is drilled through the honeycomb panel and a spacer installed. The spacer provides sufficient compressive strength to hold the panel securely without crushing the immediate area. At the same time, the spacer allows maximum tightening of the fasteners which hold the panel to the desired structural member.

*Panel joints*—Stresses distributed in and by fasteners result in stress concentrations that are difficult to define. In the past, successful designs have been more dependent on the specific application of previous experience than on mathematical calculations. The two types of joints most commonly used to hold honeycomb sandwich panels together are bonded lap joints and mechanical joints. Some of the different types of joints used are shown in Fig 2.

Lap joints are made by bonding the skins of two or more panels together with adhesive. During welding, the facings are subjected to tension or compression in a direction parallel to the facing surface, and stress concentrations exist at the ends of the lap in the facing and the adhesive. Stress concentrations in the adhesive are shear and tension (or compression) in a direction normal to the surface of the panel; in the facings, tension or compression. There are also sharp changes in the core shear stress which are dependent upon the amount of overlapping and type of load applied.

*Panel close-out*—The possible

methods for closing out panels seem limitless, and Fig 3 indicates just a few of the successful ones. Edge close-out is a special variation of fastening and becomes important when fasteners must be placed at the panel edge. The most important thing to be considered when selecting a close-out method is that all parts of the panel and close-out element, if it is a separate part, should be designed to fit well. This will assure good bonds during panel fabrication. Fundamentally, edge close-out should be designed for proper and adequate shear load transmittal, prevention of edge peel, and ease of fabrication.

### *Designing the Whole Panel*

From the design considerations discussed in Part 1 and the fastening considerations discussed in this article, it is clear that honeycomb sandwich panels, while they may be viewed as monolithic structural units in the finished state, are actually complex assemblies that are only as efficient and effective as the designer makes them. The designer has many variables, each interacting on the other, which must be kept in mind. Core size, cell wall thickness, bonding agent, skin gage, fastening techniques—all have a direct effect on the performance of the finished panel. No single variable can be considered without taking note of tentative decisions that have been made on the other options.

Effective design with honeycomb is therefore dependent in part on long term experience, combined with a basic understanding of the design principles involved. The payoff is in the form of products and parts which exhibit the unique advantages that only honeycomb structures can impart.

# Nonstructural applications of honeycomb

Because of its unique configuration and characteristics, honeycomb finds wide application in various engineering fields. In addition to honeycomb's high strength-weight ratio, which makes it ideal for structural applications in aircraft, missiles, and building construction (interior and exterior), such properties as low volume and large surface area, as well as air and light directional properties, make it an ideal material for solving a variety of engineering problems.

**Gas turbine seals**

One problem that honeycomb solves is that of sealing turbine pressure in gas turbine engines. The difficulty of sealing the stages of these engines has received much attention from aircraft engine manufacturers for many years. More recently the automotive industry has been working to develop gas turbines with efficiencies that would permit this type of power source to be used in future automobiles.

Gas turbine seals of this type must seal between the tips of the rotors and the housing of the engine to maintain proper gas flow. Standard labyrinth seals must allow enough clearance so that differences in thermal expansion of the housing and rotor do not cause interference. (The temperatures in the turbine stages of these engines may range from 400 to 1500 F.) If the seals are fitted too closely, interference fits develop which could destroy the engine; if fitted with too much clearance, the efficiency of the engine is considerably lowered.

Honeycomb half sandwiches, constructed into annular shapes with one facing on the o.d., have solved this problem by providing the closest approach to a zero-clearance dynamic seal obtainable.

The most suitable honeycomb for these seals has been found to be a welded stainless steel configuration with cells from ⅛ to ¼ in. in size. These honeycomb seals are heavy-walled and have a density of 50 to 60 lb per cu ft, as compared with aircraft honeycomb core with a density of 6 to 8 lb per cu ft. When the seal is installed, there is actually no clearance between the honeycomb and the rotor. The first time the engine runs, the rotor cuts a smooth path into the honeycomb seal. This path then allows the honeycomb to fit closer to the rotor than any other known seal.

**Oil seal**

Another dynamic seal which is constructed from a similar stainless steel annular ring is used as an oil seal on the crankshaft of an internal combustion engine. In this seal, however, there is no destruction of the honeycomb seal in direct contact with the crankshaft. Stainless steel is used for this seal because of its corrosion resistance and high temperature properties. It has excellent wear resistance properties for this application. Because there is relatively little surface contact between the seal and the crankshaft, friction is kept to a minimum and, at the same time, optimum sealing provided.

**Heat radiator**

Large surface area and low volume also make honeycomb an ideal heat radiator. Large sheets of honeycomb are now being installed in nuclear power plants for this purpose. When attached

*(continued on p 167)*

**MORE ENGINEERING & DESIGN**

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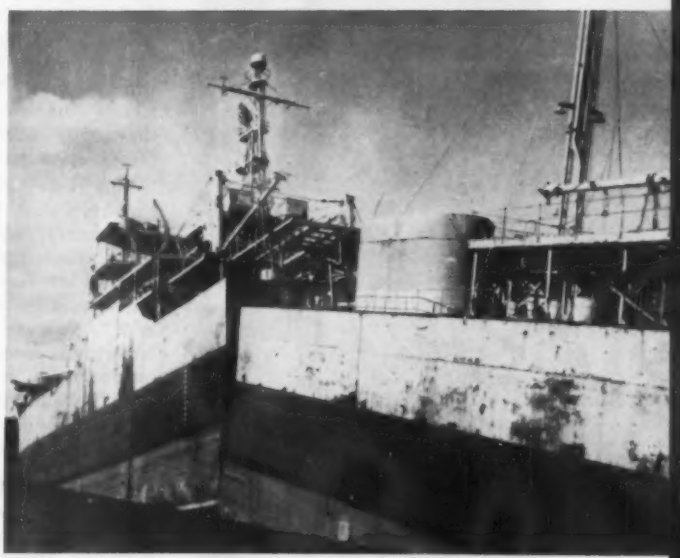
# Why Metals Break And What To Do About It

*An up-to-date summary of present knowledge concerning the fracture of metals. Written by a metallurgist for engineers in all industries, it includes:*

- *Current theories of fracture*
- *A practical approach to . . .*
  - *Fatigue failures*
  - *Brittle failures*
  - *Tensile and stress corrosion failures*
- *Some helpful case histories*
- *A selected bibliography*

**by Donald Peckner,** *Associate Editor, Materials in Design Engineering*

**M/DE Manual No. 169—April, 1960**



Top—Allis-Chalmers Mfg. Co.
Bottom—National Bureau of Standards

***Catastrophic failure** is a characteristic of brittle fracture. The seriousness of such failures is obvious in these photos.* ***Top**—A power generating station after brittle failure of a steam turbine spindle.* ***Bottom**—A tanker after it cracked in half sitting at the dock.*

**Fracture surface** *of forged steel axle. Arrow shows grooved area.*

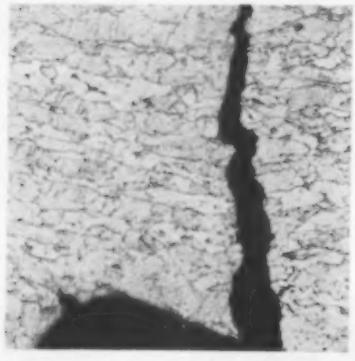
**Decarburization** *of axle surface.*

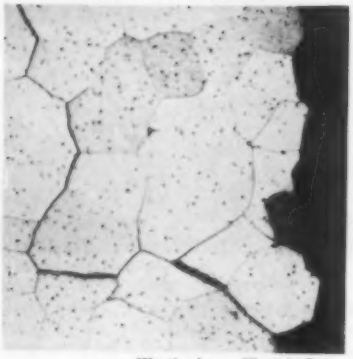
## Fatigue failure: truck axle

The forged steel axle surface was badly decarburized. In addition, there were transverse grooves where forging flash had been removed. Both factors acted cumulatively to seriously lower fatigue strength. Fracture originated at the edge of the grooved area. (National Bureau of Standards)

# What is fracture?

Fracture can be defined simply as the separation of a continuous body into two or more parts as a result of the application of stress to the body. It is a commonplace occurrence in both industry and the home.





Westinghouse Electric Corp.

***1**—Transgranular fracture (top) and intergranular fracture.*

Both the fatigue failure of a punch press crankshaft and the statement of an automobile mechanic that a part failed because it "crystallized" are well-known.

This report, dealing with fracture of metals, does not attempt to offer cure-alls for fracture problems. It is true, however, that most service fractures occur because engineers and designers fail to correlate the properties of metals with the total environment in which the metals will operate. Thus, behavior of metals under stress must be thoroughly understood before the frequency of failure can be reduced.

This report will discuss the principal types of failure encountered in industry, some of the theories that underlie the study of the entire problem of fracture, and some of the tests used to determine resistance to fracture. It will present case histories of revealing failures. Most important, it will point out clearly where fracture may occur and how to avoid some types of fractures commonly encountered.

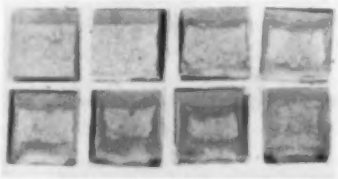
### Three types of fracture

Only three basic types of fracture have been observed in metals: grain boundary fractures; cleavage fractures through the grains; and shear fractures through the grains (see Fig 1).

The fracture path, at ordinary temperatures and at low temperatures, is normally through the grains rather than around them—i.e., shear or cleavage fracture. At elevated temperatures, the reverse is true: fracture occurs along grain boundaries. Shear, or slip, fractures can be visualized as a deck of cards sliding over each other; cleavage is akin to the splitting of mica into sheets. Each type of fracture can be identified by macroscopic or metallographic examination (see Fig 2).

### Appearance of fractures

Shear fractures are fairly dull and appear as gray silky surfaces. Cleavage failures, on the other hand, present a bright, granular surface after fracture. A cleavage (or brittle) fracture also usually exhibits a minimum of plastic flow before separation, while the shear (or ductile) fracture surface always shows evidence of some plastic flow prior to separation.



Westinghouse Electric Corp.

***2**—Cleavage (brittle) fracture, shear fracture, and a combination of both obtained on Charpy-V impact specimens tested at different temperatures. Top row—1%, 20%, 40% and 50% shear. Bottom row—60%, 70%, 80% and 99% shear.*

## Brittle failure: forged ring

The forged ring of SAE 3335 steel was fabricated in 1913 and was in service over 40 years as part of a high speed rotating machinery component. Then the 58-in. ring burst, causing considerable damage to surrounding equipment and facilities.

Visual examination of the ring showed cumulative heavy electrical arcing along the sides of a keyway at which fracture originated. Metallographic examination of the original fracture source revealed short disconnected cracks in the arc-strike area. Metallographic examination also revealed that the ring had been temper-embrittled (i.e., there was evidence of an embrittling grain boundary precipitate) by the manner in which it was heat treated in 1913. Although failure could have begun at any time during its service life, the ring did not fail until a crack developed as a result of cumulative electrical arcing.

A drop weight test of the material showed NDT was 180 F. Failure occurred at 110 F.

(Naval Research Laboratory)

# How does fracture occur: some current theories

Any discussion of fracture would be incomplete without some consideration of the theories concerning fracture. Fracture theory has not reached the point where any of the existing theories can explain all of the experimental results, even though many fracture characteristics are understood qualitatively. Fracture is a more complex phenomenon than existing theories postulate, and laws have not yet been formulated that will permit calculation of exacting fracture conditions.

*Real metals not as strong as theory predicts*—Tests with metals show that maximum theoretical strength always exceeds test results by a factor ranging from 100 to 1000. This lack of agreement between theory and experiment has led to the conclusion that real crystals are not perfect. *Griffith*, on the basis of his work with glass fibers, concluded that microcracks are responsible for the low values of fracture strength. According to him, microcracks are present in real materials and will grow, or propagate, only when such growth would reduce the free energy of the system.

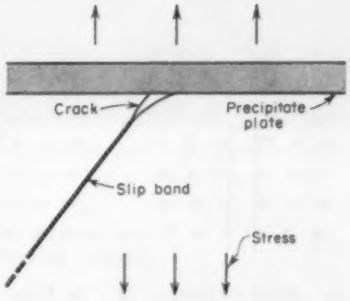
### How do cracks form?

*Stress plus dislocations help:* It has been proposed by *Zener* that as an array of dislocations moves along a slip band and meets an obstacle, such as a grain boundary or a hard particle, the dislocations begin to pile up at the obstacle. This situation is shown schematically in Fig 3 and 4. The shear stress relaxes in the slip band behind the piled-up dislocations, and the stress concentration ahead of the piled-up array increases.

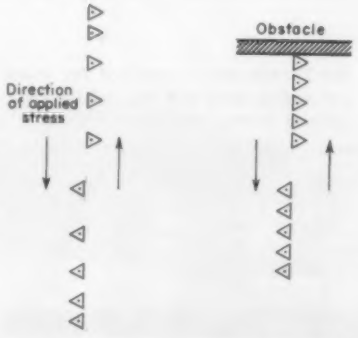
As a result of this increase in stress concentration, several possibilities arise. If the dislocations pile up at a grain boundary, the stress may simply initiate a new slip band in the next grain. But whether the dislocations pile up at a grain boundary or at a hard particle, the stress concentration may initiate a crack. Unless the crack has such a high stress concentration that it becomes self-propagating, however, complete relaxation of shear stress in the slip band will result in the microcrack not propagating further.

Formation of crack nuclei, based on the dislocation picture, was also proposed by Zener. Introducing edge dislocations into the lattice causes many small crack nuclei to form, as shown in Fig 5. As the lattice is stressed, these nuclei may coalesce into larger nuclei whose volumes greatly exceed those of the original ones.

*Cracks may already be present:* It has been shown by *Swift* that if a bar of metal is twisted in torsion until it becomes brittle, subsequent pulling in tension will produce a helical fracture surface. If the twisted bar is untwisted before tensile testing, the bar will show a normal cup-and-cone, or ductile, fracture.




**3**—*Slip band may initiate a crack upon striking a precipitate plate.* *(Zener)*




**4**—*Dislocation representation of a slip band.* ***Left***—*Normal condition: note higher density of dislocations at ends of band.* ***Right***—*Dislocation density increases when slip band strikes an obstacle, such as a grain boundary. As dislocation density increases, stress at head of slip band also increases.* *(Zener)*

Such behavior is consistent with the assumption that microcracks existed in the metal prior to testing. If microcracks were already present in a bar twisted in torsion, they would become oriented as in a helix. Subsequent untwisting, or straightening, would realign the cracks in their original orientations.

The effect of microcrack orientation on fracture strength was also considered by *Hollomon*. He assumed that randomly oriented microcracks may adopt a preferred orientation during plastic flow. Therefore, fracture strength would be anisotropic, i.e., fracture would be more likely to occur in certain directions than in others.

*Another theory:* An answer to the question of how cracks form in solids was recently suggested by *Gilman*. A crack in a zinc crystal is shown in Fig 6. The kink boundary below the crack has split into two parts, the part with the large angle moving to the left and that with the small angle, to the right. Since the applied stress in the horizontal direction is compressive, it could not have supplied the shear stress required to move the boundaries in opposite directions. If plastic shearing occurs on one side of a boundary and on a single glide system, and if the boundary does not move to bisect the new misorientation angle, large tensile stresses will be developed parallel to the boundary, which may lead to cracking.

Based on this analysis, Gilman feels that wherever there is a subboundary or other type of boundary (grain, twins, precipitate) that cannot move to accommodate a shear strain discontinuity, large tensile stresses will develop parallel to the boundary. It should be noted that dislocation pile-ups are not necessary in Gilman's mechanism, although they may act to intensify stresses locally.

**How do cracks propagate?**

The work required to propagate a crack is given by Griffith's formula:

$$\sigma \simeq \sqrt{E\gamma/c}$$

where $\sigma$ = tensile stress required to propagate a crack of length $c$
$\gamma$ = surface energy of fractured faces
E = Young's modulus

*Orowan* modified the Griffith theory to include a plastic strain energy factor, $p$, since some plastic flow is always found near the fracture surface:

$$\sigma \simeq \sqrt{E\ (\gamma+p)/c}$$

When the temperature is above the transition temperature, $p$ is large and the stress, $\sigma$, required to make the crack grow will also be large. Below the transition temperature the metal is brittle and $p$ will be smaller. The stress necessary to cause crack growth, therefore, will be reduced. The reason for the increasing speed of crack propagation, once a crack has started, is clear from both Griffith's and Orowan's equations: as the crack grows in length, the stress required for propagation continually decreases.

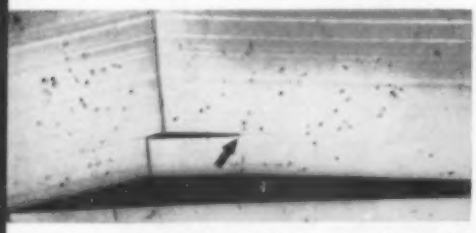
**5**—*How a possible fracture nucleus is formed by dislocations. Circles represent atom positions.* (Zener)

**a.** *Edge dislocation is formed by inserting extra half plane of atoms.*

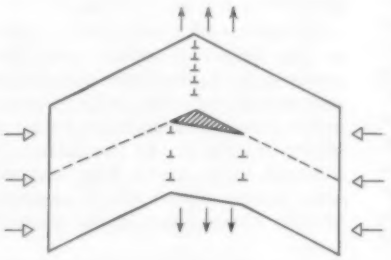
**b.** *Free energy of system is lowered when major portion of crack closes leaving nucleus for potential fracture.*

**c.** *When two dislocations coalesce, the resulting crack nuclei are more than double the original size.*

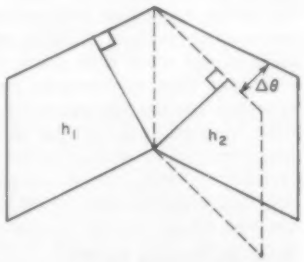
**6**—*Tensile stress required for crack formation may not depend on dislocations alone.* (General Electric Co.)



**a.** *Crack at a kink plane in a zinc crystal. Note that kink boundary (heavy vertical line) has split into two parts below the crack: Part with larger angle has moved to the left; part with smaller angle to the right (the latter boundary is not obvious and is indicated by the arrow).*



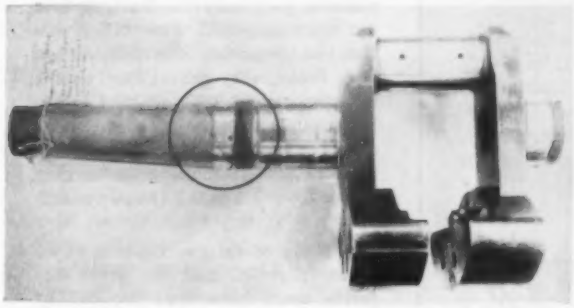
**b.** *Suggested tensile forces acting on the crystal. Edge dislocation symbols show how boundary has split into two parts.*



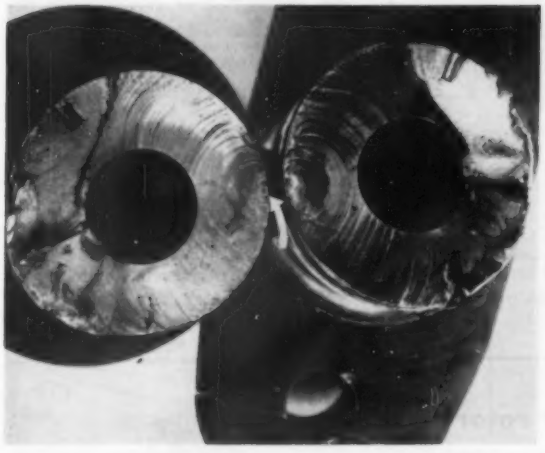

**c.** *If a boundary does not move to bisect the misorientation angle, $\Delta\theta$, then $h_2 \neq h_1$. The tensile strain produced is $h_1/h_2 - 1 = \epsilon$. Since $h_1 = h_2 \cos \Delta\theta$, $\epsilon + 1 = 1/\cos \Delta\theta$. If a strain of 2% is required to cause fracture, the change needed in the misorientation angle is 7 deg.*

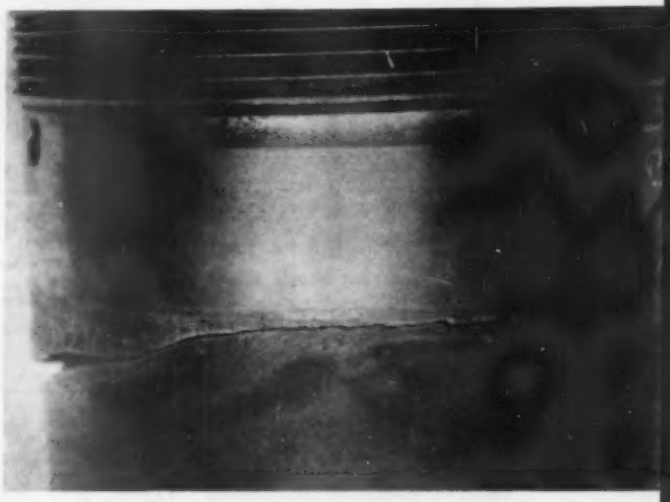
## Fatigue failure: aircraft crankshaft

Forged alloy steel part failed after 220 hr in an area where fretting had occurred under propeller hub. Fretting action pitted the surface (see photograph below, right) forming areas in which stress raisers were present. As a result, peak stress exceeded fatigue strength of the steel. (National Bureau of Standards)



***Crankshaft** with broken parts fitted together.*





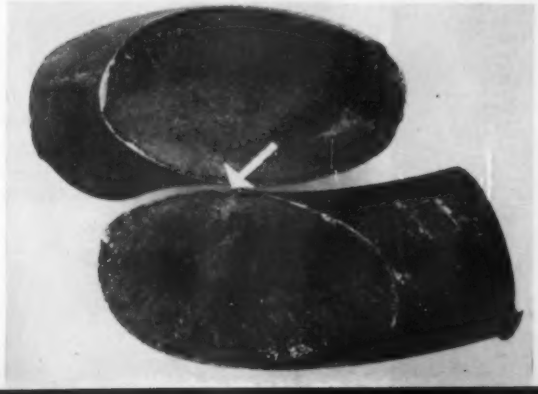
***Fretting corrosion** of shaft surface near fracture origin.*

***Beach marks** on fracture surface. Arrow indicates origin of failure.*

## Fatigue failure: helical steel spring

The surface of this steel spring was somewhat pitted, and a fatigue crack began at one of the pits. The crack progressed over nearly one-half of the rod cross section before failure occurred—an indication that applied stress was relatively low (see text). This failure shows how surface defects severely affect fatigue strength. (National Bureau of Standards)

***Spring** fitted together after failure.*



***Fatigue crack** progressed from origin (arrow) across nearly half of section before strength of remaining section was exceeded.*

## *Fatigue Data: Stress Systems Vary*

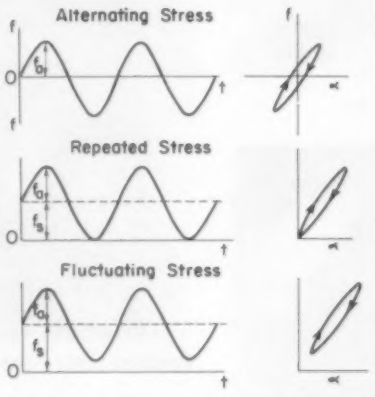
In using fatigue test data, it is important to be sure that the stress system used in testing corresponds to the service conditions expected. Stress systems used in fatigue testing fall into one of three principal categories:

1. Alternating stress combined with a static stress of the same type. Example: alternating direct stress with a superimposed static tensile stress.

2. Varying stress combined with a static stress of a different type. Examples: varying tensile stress combined with static torsion, or vice versa.

3. Combinations of two varying stresses which differ in type. Example: varying tensile stress combined with varying torsion stress.

When an alternating stress is applied with a superimposed static stress, furthermore, three variations of stress with time are possible: alternating, repeating, and fluctuating stress. These variations are diagrammed in the accompanying drawing. The static stress is represented by $f_s$; the superimposed alternating stress by $f_a$. When $f_s = 0$, the stresses are *alternating* (varying between two equal extremes of opposite sign with the mean stress equal to zero). If $f_s = f_a$ the stresses are *repeating* (varying between zero and some definite value, and always of the same sign—either positive or negative). If $f_s \neq f_a$, the stresses are *fluctuating* (varying between two extremes that have different finite values, and are not necessarily of the same sign).




***Three variations** of stress vs time are used in fatigue testing.*

# Fatigue failure

**What is fatigue?**

The term fatigue refers to failure of a component under the action of repeated stress. It is probably responsible for as many as 80% of all machine part failures. Fatigue does not correlate well with other mechanical properties of metals. It has been found, very generally, that the endurance limit ($\sigma_E$) of steel is approximately one-half the tensile strength ($\sigma_E \simeq 0.5\sigma_{Ts}$). In nonferrous metals the relating factor may range from 0.2 to 0.5 (i.e., $\sigma_E \simeq 0.2$-$0.5\sigma_{Ts}$).

A study of fatigue failures would probably reveal that the great majority could have been avoided by the application of sound design principles, especially those involving the elimination or reduction of potential stress concentrations.

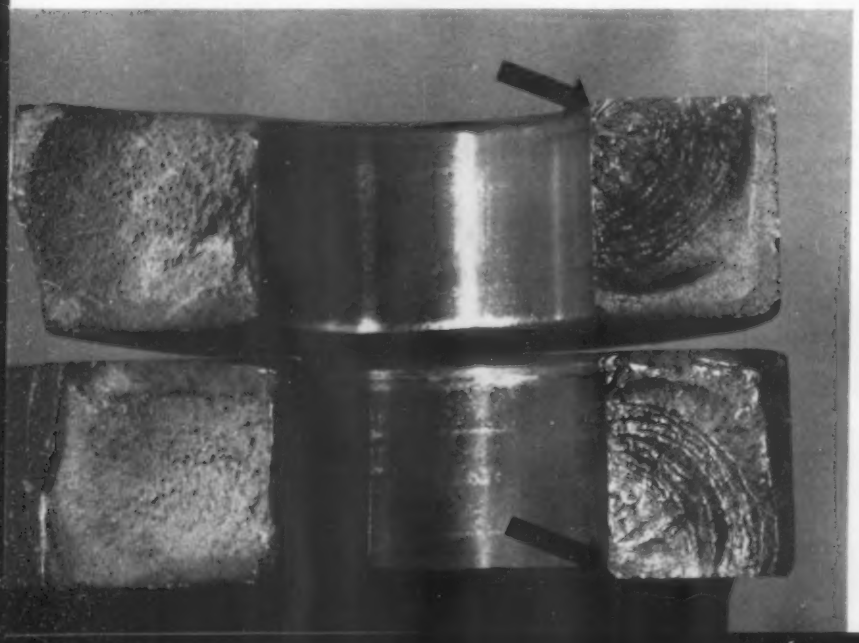
**Stress-raisers are important**

The importance of stress raisers can be shown in a simple example. If a small hole is drilled in a wide strip of elastic material (which is both homogeneous and isotropic) and the strip is subjected to a uniaxial tensile stress $s$ in a direction parallel to the direction of the strip edge, the stress reaches a maximum value of $3s$ at the hole surface.

## Fatigue failure: helicopter rotor link

No metallurgical defects were found that might have influenced failure of this 2014 aluminum forging. Origin of failure was at end of hole where a bushing was inserted. (National Bureau of Standards)

***Fracture surface.** Arrows show point where fracture started.*



***Failed** helicopter rotor link.*

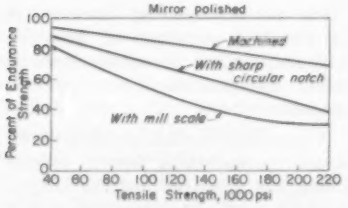
*Three broad groups of stress raisers* — The majority of stress raisers fall into one of the following broad groups:

1. Those caused by changes in the geometry of a part, such as steps at changes in diameter, abrupt corners, holes, keyways, threads, press or shrink fittings, junctions of bolt shanks and heads, etc.

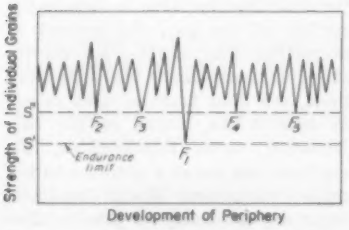
2. Surface discontinuities, such as nicks, notches, machining marks, pitting, corrosion, etc.

3. Defects inherent in the material, such as nonmetallic inclusions, local discontinuities, minute cracks, voids, etc.

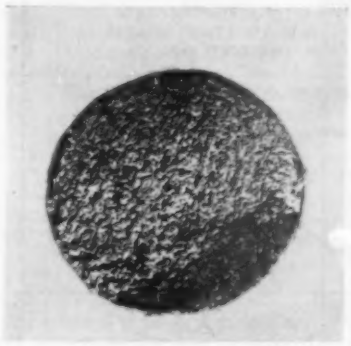
Primary stress raisers are usually of the first group, although those of the second and third groups may play secondary, related roles. For example, an area of stress concentration may develop in a shaft where a diameter change occurs. If a machining mark is located in the transition area, the stress concentration will be further intensified. A nonmetallic inclusion in the area will add to the stress concentration. The effect of all three stress raisers may be great enough so that the stress exceeds the endurance limit of the material and initiates a fatigue crack.

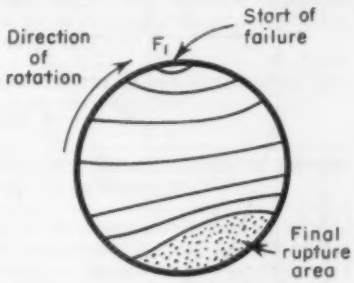



**7**—*Endurance limit may be reduced by surface conditions.* (*Adapted from Karpov.*)



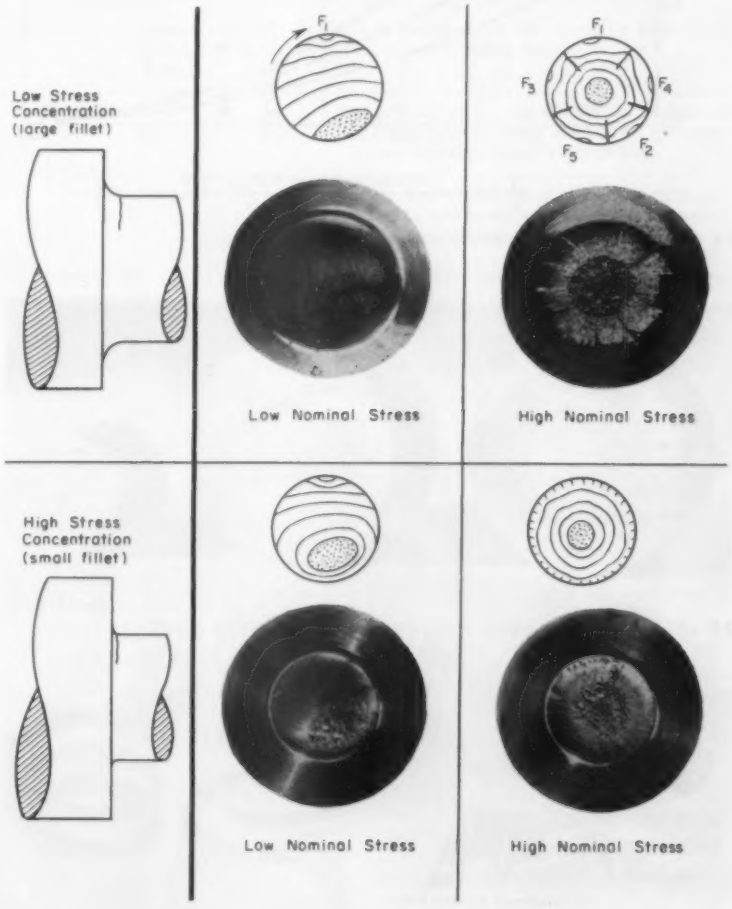

**8**—*Strength of individual grains varies. Under stress $S_1$, a crack might form at grain $F_1$. Under stress $S_2$, cracks might form at several grains.* (*Peterson*)



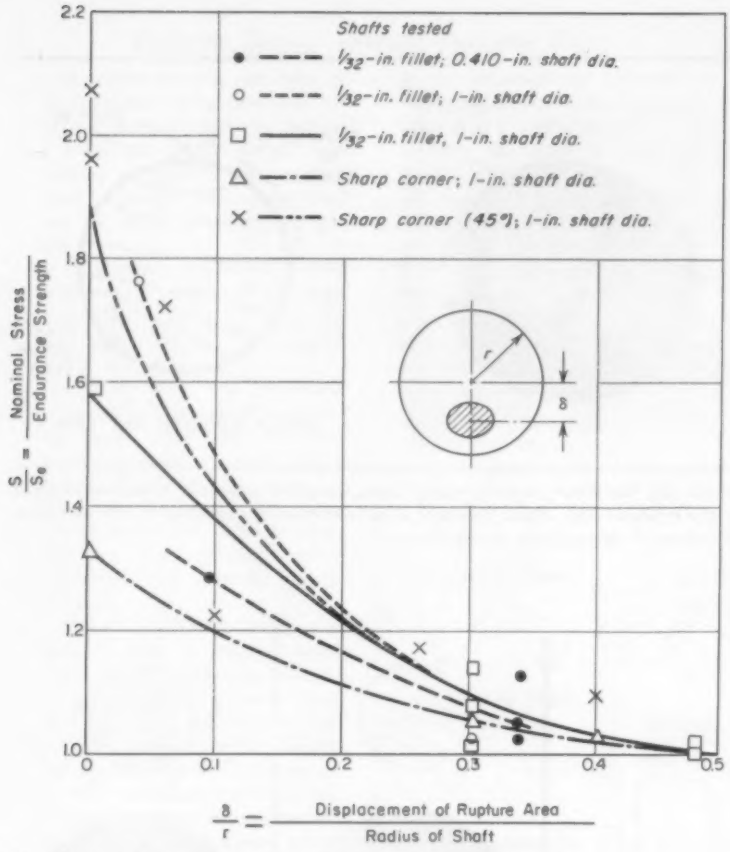



CRACK GROWTH PATTERN

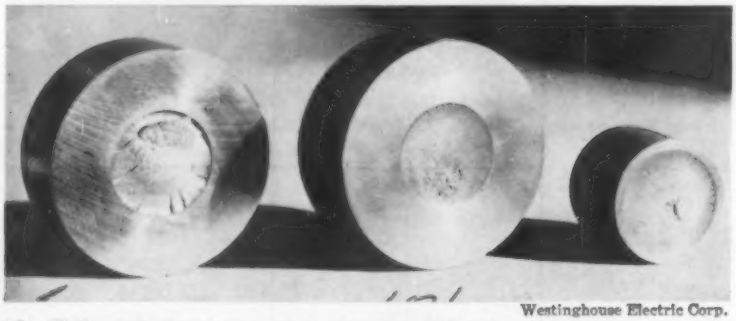
**9**—*In the "no stress concentration" case, fracture proceeds from one surface to the opposite one. Final fracture area is displaced according to the direction of rotation.* (*Westinghouse Electric Corp.*)




**10**—*Stress concentration affects fatigue fracture appearance.* (*Peterson*)

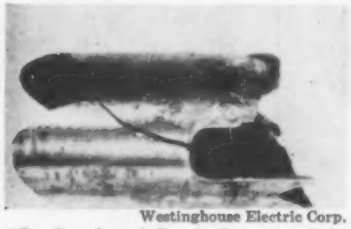



**11**—*Final rupture area shifts with stress level.* (*Peterson*)



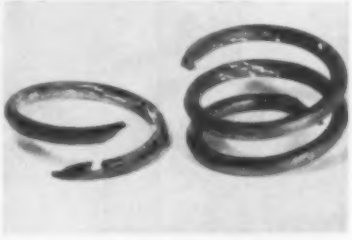
Westinghouse Electric Corp.

**12**—*Shift of final rupture area is shown on laboratory specimens.*



Westinghouse Electric Corp.

**13**—*Service failure due to alternating torsion.*



**14**—*Fracture of a helical spring.*

Fig 7 shows how the endurance limit can be reduced by changing the surface conditions.

**Analyze fatigue failures: 'read' the fracture surface**

By examining the fracture surface—either macroscopically or microscopically—and by proper interpretation, it is possible to determine the origin of a fracture and the degree of overstressing that preceded failure.

*Bending*—Fatigue fracture surfaces usually show both smooth and coarse areas; the surface is smoothed by the repeated opening and closing of the crack; the coarse area results from final rupture.

How does fatigue failure begin? Plotting the strength of individual grains around a peripheral circle would show that strength varied from grain to grain (see Fig 8). A stress just above the endurance limit, $S'$, might cause a crack to form at grain $F_1$. In a case of bending fatigue, with no stress concentration involved, the crack will progress from grain $F_1$ and spread across the shaft, with the rupture area displaced in a direction related to the direction of rotation (see Fig 9). Raising the stress level to $S''$ (Fig 8) causes failure to begin simultaneously at several additional points ($F_2$, $F_3$, $F_4$, $F_5$) around the shaft periphery.

Fig 10, developed by *Peterson*, is an excellent summary of how the fracture surface is related both to stress concentration and service stresses.

A quantitative relationship between stress concentration factor, service stress, and appearance of the fatigue fracture surface is presented in Fig 11. The combination of these three parameters can be used to determine the extent to which applied stress exceeded endurance limit. If the final fracture area is close to the surface of the bar, the amount of overstress was slight. As service stress increases over the endurance limit, the final fracture area moves in toward the center of the bar. Knowing these relationships, the engineer can see at a glance whether major component design modifications are necessary to prevent further failures.

Fig 12 shows the fracture surface of laboratory test specimens subjected to varying conditions of stress and stress concentration. Ac-

cording to Peterson, a centrally located rupture area is an indication that the part probably failed in fewer than 300,000 cycles; several million cycles are required to cause near-peripheral rupture areas.

Beach marks are often found on service fractures. Since they usually indicate that a long period is required for crack propagation, the degree of improvement needed to prevent failure in such cases is not large.

*Torsion*—Torsion fatigue failures usually follow a path 45 deg to the specimen axis (see Fig 13). Failures caused by bending or axial loading do not produce the diagonal crack. Helical springs that fail in torsion have a characteristic fracture surface associated with torsional failure as shown in Fig 14. Another interesting fracture surface associated with torsional failure is shown in Fig 15.

### What to do about fatigue

As pointed out in the introduction, the designer must have some knowledge of the total environment in which a part will operate. This information can be used to determine probability of failure before a component is put into service. Twelve conditions that may have an adverse effect on fatigue life are presented in Table 1.

Most cases of fatigue failure can be traced to poor design details or errors in processing. Eliminating severe stress raisers by using generous fillets, and by carefully controlling fabricating techniques, are useful cures for the problem. From the general information in Table 1, it is evident that resistance to fatigue failure can be improved by:

1. Eliminating stress raisers.
2. Designing to take stress raisers into account when it is apparent that they cannot be eliminated from the design.
3. Avoiding surface tears such as those caused by punching, shearing, etc.
4. Controlling heat treatment to prevent decarburization, oxidation, etc.
5. Improving fabricating and fastening details in the design.
6. Protecting the part from corrosion, erosion, etc.
7. Insofar as possible, guarding against the formation of surface defects in service.

**TABLE 1—TWELVE CONDITIONS THAT REDUCE FATIGUE STRENGTH***

| | Condition | Result |
|---|---|---|
| 1 | Stress concentrations due to improper design (small fillet radii in shafts or changes in section) | Reduction in fatigue strength depends on the geometric factor and on sensitivity of the material to notches. Can be as high as 4:1 |
| 2 | Stress concentrations due to improper manufacturing (file marks, rough machined surfaces) | More difficult to evaluate, since geometry of notches is usually of a nonstandard form |
| 3 | Residual tensile surface stresses caused by grinding | Improper grinding can introduce high tensile stresses, causing a marked loss of fatigue strength |
| 4 | Residual tensile stresses due to cold forming | Although beneficial compressive stresses can be introduced by cold forming, in some cases tensile stresses are introduced, causing a loss of fatigue strength |
| 5 | Fretting or galling of surfaces that are simultaneously subjected to fatigue stresses | Fretting or galling can cause a severe loss of fatigue strength. All clamped or riveted joints are subject to this condition |
| 6 | Corrosion | Corrosion from moisture or liquids in general causes a large loss of fatigue strength. Most metals require adequate surface protection |
| 7 | Plating | Plating usually reduces fatigue strength of the part, the amount depending on the type of plate, its thickness, and the method of plating |
| 8 | Surface conditions introduced by heat treatment (oxide penetration, decarburization, etc.) | Only by careful control can the surface be protected during the heat treating process |
| 9 | Size Effect | Most published fatigue data on materials are based on small laboratory specimens which do not adequately evaluate the fatigue strength of large parts |
| 10 | Speed Effect | Although speed of stressing has only a minor effect over a large range of speeds, very high or very low speeds will usually cause lower strengths |
| 11 | Shape Effect | It has been found that shape has some influence on fatigue strength |
| 12 | Assembly Stresses | Tensile stresses induced by assembly have an adverse effect on fatigue strength |

*Adapted from *F. B. Stulen* and *H. N. Cummings*.

Westinghouse Electric Corp.

**15**—*Service failure of an automobile torsion bar due to alternating torsion.*

# Brittle failure

**What is it?**

Brittle failure is a sudden catastrophic rupture resulting in a bright crystalline cleavage or grain boundary fracture surface. These failures are usually associated with very small amounts of prior plastic deformation. (However, as will be pointed out later, a considerable amount of plastic strain, or ductility, may precede brittle fracture in some cases.)

*Started with first steel structures:* Brittle failures have been reported as far back as 1879. Although ship failures are the most widely known, perhaps, failures have also included bridges, pressure vessels, storage tanks, gas transmission pipe lines, and power shovel booms. The problem was given national attention by the Bureau of Standards and the Bureau of Ships after 250 welded ships suffered brittle fractures of such severity that the ships either sank or were put out of action. These failures were recorded in the period between 1942 and 1952. During the same period, 1200 welded ships were damaged by brittle cracks that did not exceed 10 ft in length.

One of the more unusual failures attributed to brittle failure occurred in Boston in 1919. A molasses tank holding 2,300,000 gal of molasses failed catastrophically. Twelve persons were drowned in molasses or died of injuries, 40 others were injured, and many horses drowned. Houses were damaged and a portion of the Boston Elevated Railway structure was knocked over. The state of knowledge of brittle fracture at that time was nil. After much conflicting expert testimony the court-appointed auditor stated, in part, "Amid this swirl of polemical scientific waters it is not strange that the auditor has, at times, felt that the only rock to which he would safely cling was the obvious fact that at least one-half of the scientists must be wrong."

*Three conditions for failure:* Since then enough has been learned so that we know that all three of the following conditions must be met if brittle fracture is to occur:

1. A stress raiser, resulting from either design or fabrication defects, must be present.
2. Localized yielding must occur in the vicinity of the stress raiser.
3. The material must be below the ductile-to-brittle transition temperature.

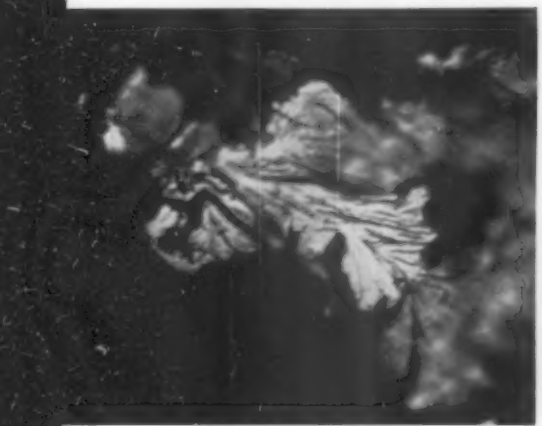
**Which metals are affected?**

Ductile-to-brittle transition is most prevalent in metals having a body centered cubic (bcc) lattice structure. In such metals, yield strength is strongly dependent on temperature and rate of straining. On a qualitative basis, at least, the concept of the transition temperature is that brittle, or cleavage, failure

## *Fractography Answers Many Questions About Failures*

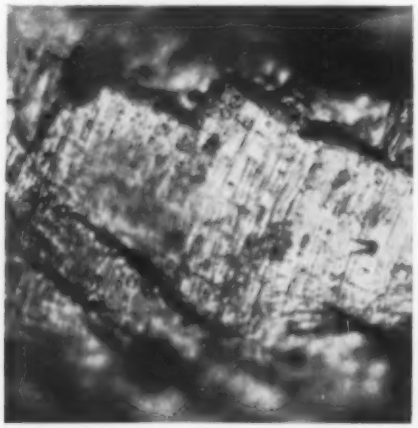
Many characteristic marks on fracture surfaces cannot be distinguished without microscopic examination. Fractography is the term applied to microscopic study of fracture surfaces using magnifications ranging from a few diameters (macro-examination) to several thousand diameters (electron microscopy). The most useful magnifications lie in the range from 250 to 650 X.

Fractography is used to determine the mode of fracture (shear, cleavage, intergranular). It is also used to determine both the origin of fracture and the location and nature of flaws that may have initiated failure. Once this information is obtained, the answer to why a part failed can usually be determined. The accompanying photographs illustrate the use of fractography.



***Intergranular fracture*** *resulted from Charpy V impact test of a steel at –150 F.*

***Cleavage fracture*** *occurred in a steel tested at –100 F.*



***Beach marks*** *are obvious on fracture surface (1100X) of specimen that failed in fatigue at room temperature.*

occurs when yield strength, i.e., the stress at which plastic flow begins, is higher than the cleavage fracture strength. This condition can be achieved either by decreasing the temperature or by increasing the strain rate. The temperature dependence of yield strength and ductility of some bcc metals is shown in Fig 16.

Face centered cubic (fcc) and close packed hexagonal (cph) lattices show varying response to temperature change as shown in Fig 17. The fcc metals show no temperature dependence and, in actual practice, are not subject to brittle failure. The cph metals can behave in either fashion. Rhenium shows a complete loss of ductility and a strong variation in yield strength with temperature. Titanium behaves in a manner similar to rhenium, but zirconium behaves like the fcc metals.

**Transition temperature is key**

*How does it affect fracture tendencies?* The effect of temperature on the performance of steel can be related to three critical fracture transition temperatures. These are:

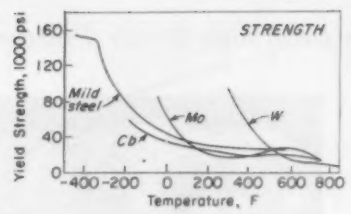
1. NDT (nil ductility transition). Below this temperature, the steel does not deform (for all practical purposes) before fracture occurs. Fracture occurs immediately and catastrophically when the yield point is reached. The fractures propagate easily through the elastic load regions.

2. FTE (fracture transition for elastic loading). At this temperature—higher than NDT—plastic deformation is required to initiate fracture. As temperature is lowered to approach NDT, the amount of plastic deformation required falls off rapidly.

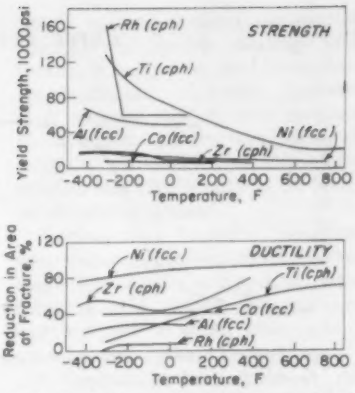
3. FTP (fracture transition for plastic loading). Above this temperature—which is higher than FTE—brittle fractures cannot propagate, even through material that is plastically deformed severely by high overstressing.

*Pellini* has determined that FTE occurs approximately 50 F ± 10 F above NDT; FTP is usually approximately 100 F ± 20 F above NDT.

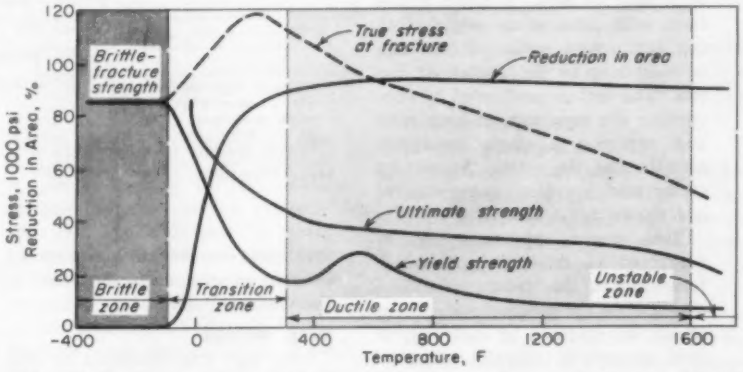
Table 2 correlates NDT with service failures. In all cases, tests during the failure investigation showed that the component was operating above its NDT. All of these failures could have been avoided by designers familiar with brittle failure criteria.




**16**—*Ductility and yield strength of body centered cubic metals are affected by temperature.* (Wessel)




**17**—*Ductility and yield strength of face centered cubic and close packed hexagonal metals as a function of temperature.* (Wessel)



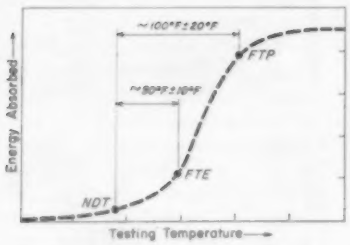

**18**—*Effect of temperature on the flow and fracture characteristics of annealed molybdenum.* (Bechtold)

**TABLE 2—CORRELATION TEST DATA SHOW THAT BRITTLE FRACTURES OCCUR BELOW TRANSITION TEMPERATURE**

| Failure Type | Failure (Charpy V) | | | | NDT (Charpy V) | | | |
|---|---|---|---|---|---|---|---|---|
| | Temp, F | Ft-Lb | Shear, % | Lat. Exp., in. | Temp, F | Ft-Lb | Shear, % | Lat. Exp., in. |
| World War II Ships | 35 | 8 | 5 | — | 50 | 10 | 9 | — |
| | 5 | 5 | 4 | 0.007 | 30 | 9 | 12 | 0.014 |
| Pressure Vessels | 45 | 5.5 | 9 | 0.007 | 60 | 6 | 15 | 0.009 |
| | 60-70 | 6-7 | 6-8 | 0.008 | 80 | 8 | 10 | 0.011 |
| | 45 | 3.5 | 4 | 0.004 | 110 | 7 | 17 | 0.011 |
| | 55-60 | 8-9 | 7-9 | 0.008 | 70 | 10 | 11 | 0.011 |
| | 55-60 | 18-20 | 9-10 | 0.020 | 100 | 32 | 24 | 0.030 |
| Anchor Windlass | 70 | 5 | 4 | 0.006 | 100 | 7.5 | 7 | 0.010 |
| Forged Ring | 115 | 4.5 | — | — | 180 | 8.5 | — | — |
| Retaining Ring | 70 | 5 | 0 | 0.004 | 400 | 14.5 | 26 | 0.010 |
| Propeller | 30-40 | — | — | — | >210 | — | — | — |

Fracture transitions are commonly determined by means of the Charpy V-notch impact test (see box p 138), but may also be determined on the basis of laboratory tensile tests. The effect of temperature on the flow and fracture characteristics of annealed molybdenum specimens is shown in Fig 18. Starting at about 300 F, yield strength increases rapidly as testing temperature decreases. This increase can be followed to about −100 F, but at lower temperatures fracture occurs before

## *Three Tests Determine Brittle Fracture Tendencies*

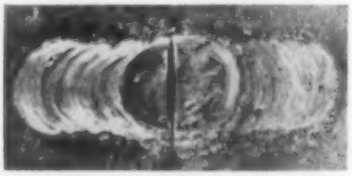


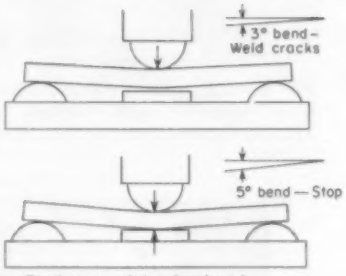

***B** Typical energy curve obtained from Charpy V-notch test.*

### Charpy V-notch impact

This test uses a small specimen, 10 x 10 x 55 mm. A notch 2 mm deep, with sides at an angle of 45 deg and a root radius of 0.25 mm is machined in the center of the bar. The test is performed by supporting the specimen at both ends and applying a single pendulum blow behind the notch. An impact tester and a typical energy curve are shown in *A* and *B*.

The impact specimens can be examined to determine at which temperature the fracture surface appears to show some evidence of shear, no evidence of cleavage, or 50% shear-50% cleavage. Since all three criteria have been used to determine the transition temperature, some corroborating test should be used to implement the value of the Charpy-V data.


Crack in Brittle Weld

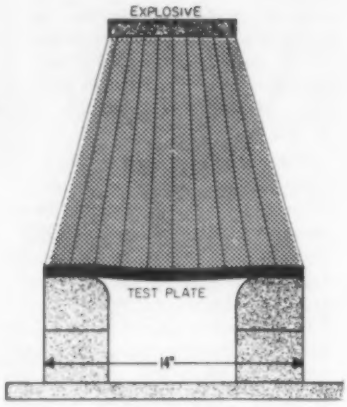



***C** Drop weight test specimen and test procedure.* *(Puzak and Pellini)*

### Drop weight

This test was developed by Pellini, Puzak and their associates at the Naval Research Laboratory while investigating the brittle failure of ships. It measures the susceptibility of steel to the initiation of brittle fracture.

Pertinent features of the drop weight test are shown in *C*. A cleavage crack (which represents the sharpest possible notch) is introduced by means of a brittle hardfacing weld deposit. A weight is dropped on the specimen sufficient to deflect it 5 deg. Magnitude of the weight depends on specimen size. The weld cracks after about




***D** Explosion bulge test setup.*
*(Naval Research Laboratory)*

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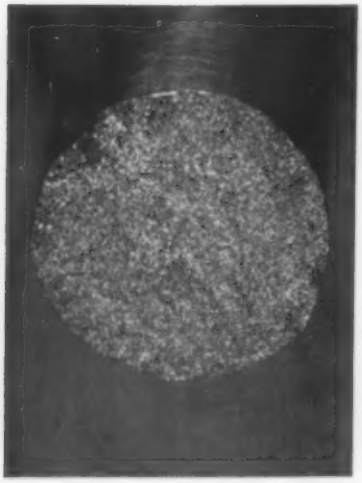
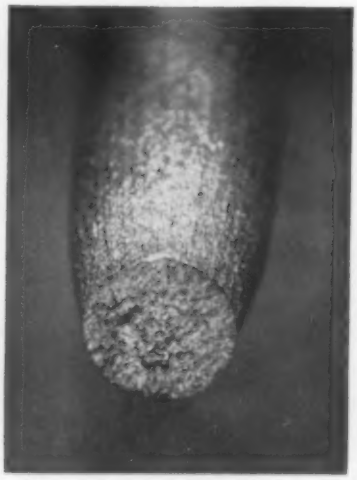
**19—*Fracture surfaces of molybdenum tensile specimens (10X).*** *(Bechtold)*



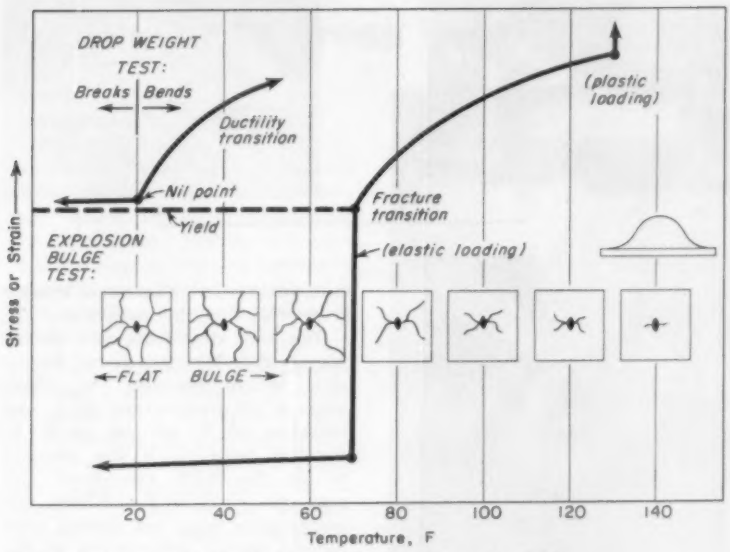
***Brittle zone (−103 F)**—Cleavage failure, no reduction in area.*



***Lower transition zone (68 F)**—Cleavage failure, 70% reduction in area.*

Westinghouse Electric Corp.

***Upper transition zone (212 F)**—Shear failure, 77% reduction in area.*




**E** *Correlation of explosion bulge and drop weight test results.*
*(Puzak and Pellini)*

3 deg deflection, and the remaining 2 deg measure ability of the steel to deform plastically in the presence of a sharp notch.

The test has good reproducibility. Correlation of NDT determined by the drop weight test with actual service failures is shown in Table 2 on p 137.

**Explosion bulge**

In the explosion bulge test, as in the drop weight test, a crack starter weld is deposited on one side of a specimen. The specimen is placed over a die and force applied by means of an explosion (see *D.*) The weld bead is placed on the tension side of the plate.

The correlation of the various transition temperatures described in the section dealing with brittle fracture with the explosion bulge test and the drop weight test is shown in *E*.

yielding. The intersection of the yield strength curve with the brittle fracture strength curve is the temperature at which molybdenum becomes completely brittle under simple tension. Below this intersection, in the brittle zone, fracture occurs at a stress below the yield strength and the surface of the fracture appears bright and crystalline.

Change from brittle to ductile behavior does not occur abruptly, but rather over a temperature range that can be considered as a transition zone. Specimens tested in the lower portion of the transition zone yield like a ductile metal but fracture in a brittle manner. In the upper portion of the transition zone, and in the ductile zone, the fracture surface appears dull and fibrous, as is typical of ductile fracture. Fig 19 shows fracture surfaces typical of those occurring in the transition zone.

*Stress ratios important:* One important aspect believed to govern brittle fracture behavior is the ratio of normal to shear stress, as shown in Fig 20. In the torsion test this ratio is 1:1; in uniaxial tension, 2:1; in notched tension it is greater than 2:1 and may be as high as 3 or 4 to 1. Increasing the ratio of normal to shear stress shifts the yield strength curve to higher temperatures and stress levels, raising the transition temperature. Lowering the temperature or increasing the strain rate for any given stress ratio raises the yield strength, with similar results.

Although this concept provides a reasonable working approach to the brittle fracture problem, as pointed out in the section dealing with theory, it cannot be used to explain the mechanism of brittle fracture. It is assumed that there is no plastic flow prior to fracture when, in actuality, plastic flow, no matter how minute, has consistently been found in all brittle failures.

*Factors that increase transition temperature:* Knowing which factors may cause a rise in transition temperature will enable the engineer and designer to avoid them whenever possible. These factors are:

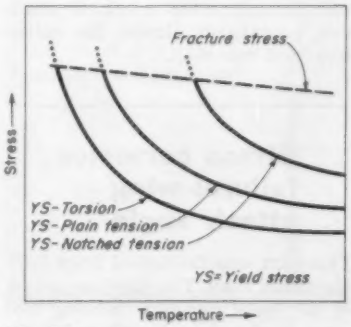
1. Recrystallization (only in refractory metals; the reverse is true for steel).
2. Decreasing amounts of cold work (only in refractory metals; the reverse is true for steel).
3. Increasing grain size.
4. Increasing interstitial content.
5. Increasing strain rate.
6. Introduction of triaxial stresses.

**Design to avoid brittle fracture**

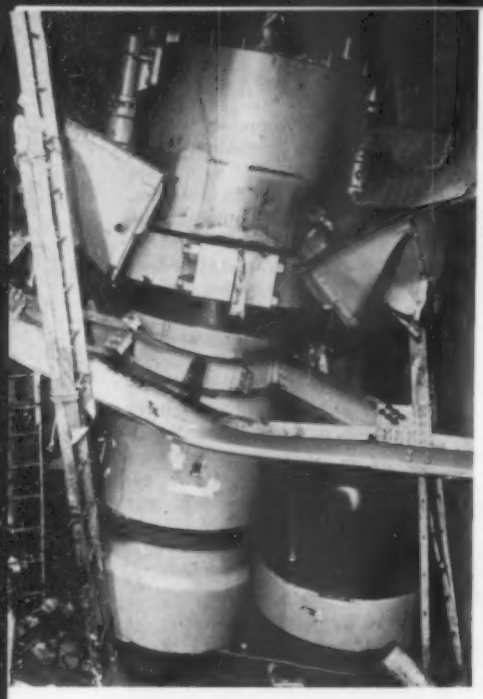
The extensive studies of welded steel structures have led to several approaches to the problem of avoiding brittle fracture. They have been summarized by *Puzak* and *Pellini* as follows:

1. Improve the notch ductility of the steel to provide for ductile behavior despite the presence of sharp-notch flaws.
2. Design to eliminate all regions of plastic flow, since brittle fracture cannot initiate if the stress level in the general area of the notch remains within the elastic range.
3. Eliminate sharp-notch flaws that may develop during fabrication.

From a practical point of view, steel users should try to use a steel that behaves in a ductile manner at all operating temperatures despite the presence of a sharp notch.




**20**—*Transition temperature as affected by loading conditions.*
*(Gensamer)*



## Brittle failure: pressure vessel

The failure illustrated shows the difficulty of eliminating all stress raisers in large welded structures. This 100-ton pressure vessel was used for pressurization cycles involving stresses up to 30,000 psi. Both ends of the vessel contained threaded breech-block-type closures forged of ASTM A293 steel. The vessel operated only at room temperature (70 F) and was pressurized three or four times each day.

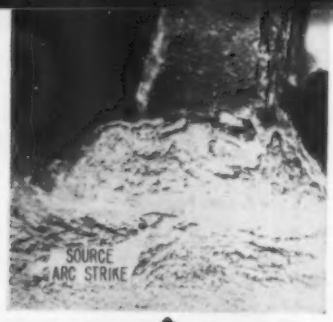
Small fatigue cracks developed in the root of the first thread of the bottom closure; after 1550 pressure cycles, brittle fracture completely severed the bottom head (shown lying at lower right). The head cantilevered out and knocked the supporting legs from position, allowing the 100-ton weight to drop and collapse the superstructure. In addition to the circumferential crack, a crack also propagated almost the entire length of the shell.

(Naval Research Laboratory)

## Stress corrosion failure: wing attach angle

This part was fabricated from 7075 aluminum alloy. The clamping action of the bolts caused a bending moment in the short leg of the angle. The resulting stress, combined with atmospheric corrosion, was sufficient to cause a crack to form despite a low service stress.

(National Bureau of Standards)



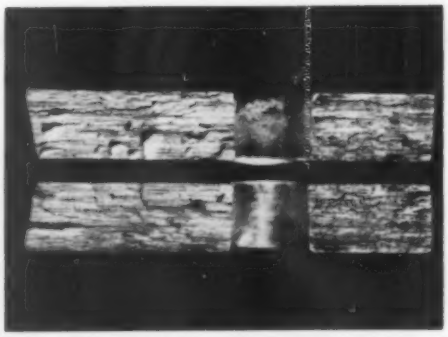
## Brittle failure: T-2 tanker Ponaganset

The USS Ponaganset broke in two in Dec '47 while tied at dockside in Boston (see p 127). Air temperature was 35 F. Failure originated at an arc-strike made in the starboard deck plate where a chock and bracket were welded to the main deck.

The 1-in. steel plate used at the source of failure was tested by the drop weight method. The plates broke at all temperatures up to and including 50 F, but not at 60 F. On this basis, 50 F was assumed to be the NDT (see text). At temperatures of 50 F and lower, the source plate could not develop even minute plastic deformation in the presence of a cleavage crack. At 35 F, in the presence of an arc-strike, brittle fracture began, as predicted by the drop weight test. At this temperature—the temperature at failure—the plate could absorb 8 ft-lb of energy and showed only 5% shear on the fracture surface. At 50 F, these values were 10 ft-lb and 9% shear.

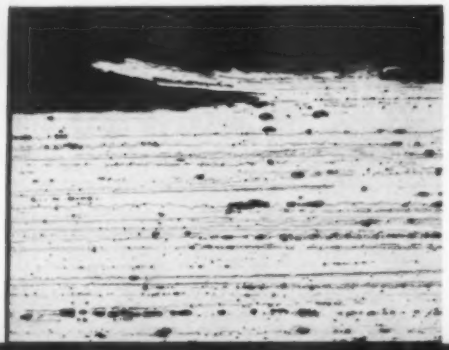
(Naval Research Laboratory)

***Cracks** in the lower attach angle were revealed by dye penetrant inspection.*



***Fracture surface** shows flakes raised when the surfaces were separated (caused by branching nature of stress corrosion crack).*

***Photomicrograph** (100X) shows that fracture tends to follow boundaries of elongated grains.*



# Tensile and stress corrosion failure

### Tensile failure

Considering the present state of knowledge concerning the properties of metals, and ways to avoid stress concentrations, service failures caused by static overloading are too common. Failure of a part in a drawing or spinning operation, or cracking on the tension side of a bend, usually occurs only when such factors are ignored.

*A case history*—On the assumption that tensile failure will not be encountered in a well designed part, we will confine our attention here to a single case history that shows how poor design concepts can lead to failure. The part involved was the shell of a heat exchanger. As shown in Fig 21, the area that failed was an embossed area—rectangular on one end and semicircular on the other. The cracks formed on the rectangular end of the section when the designer failed to take metal flow and stress concentration factors into account.

In deforming a steel sheet plastically, continuous metal flow is necessary to prevent a buildup of stress at the bend areas. In the case of this heat exchanger shell, consider the part to be an embossed cup with very large flanges. When the embossed area was formed, the metal at the very edge of the flange did not immediately begin to flow; thus continuity of flow was interrupted and a stress concentration introduced. The stress level was not raised above the tensile strength of the steel (plain low carbon) since the semicircular portion of the embossed area did not crack. At the rectangular end, however, an additional stress concentration factor was introduced at the corners. This stress, plus the preceding stress concentration, raised the stress above the tensile strength of the steel. The part could easily have been designed with a circular embossed area and failure would not have occurred.

**21**—*Tensile failure occurred during forming. Note cracks on each side of rectangularly shaped end of embossed cup. No cracks were found on semicircular end of cup.*

### Stress corrosion failure

Stress corrosion cracking can be considered as the spontaneous cracking of a steel or nonferrous metal resulting from the combined effects of corrosion and stress. It is a type of brittle fracture of normally ductile metals.

*What metals are affected?*—Stress corrosion cracking has been found in austenitic stainless steels, brass (susceptibility increases with zinc content), mild steel, lead, and magnesium alloys (as aluminum and zinc content increases).

*How to prevent cracking* — The area of stress corrosion cracking is one of conflicting theory. In practice, there are two methods of decreasing susceptibility to stress corrosion cracking.

1. Minimize residual stresses. Use design, fabrication and assembly methods that minimize stresses after fabrication. If this is not possible, stress relieve the component by heat treatment after assembly.

2. Cracking, once started, can be stopped by applying cathodic protection (see Fig 22).

Westinghouse Electric Corp.

**22**—*Crack formed by stress corrosion is completely stopped when cathodic protection is applied.*

## *What the Terms Mean*

Some of the terms used in this report may not be familiar to all readers. Here are brief definitions of important technical terms that may not be self-explanatory.

**Anisotropic.** Having physical and mechanical properties that are not the same in all directions.

**Beach mark.** A wave-like marking found in series on fatigue fracture surfaces. Each marking, or wave, indicates a line of crack arrest during the process of fatigue failure.

**Body centered cubic lattice.** A unit cell in which one atom is located at the center of the cube and one at each corner. Designated *bcc*.

**Cleavage fracture.** Failure along crystallographic planes where atomic density is low. Caused by tensile stress.

**Close packed hexagonal lattice.** A unit cell in which the atoms are located at the corners of the hexagonal cell. Designated *cph*.

**Dislocation.** An imperfection in the metal lattice which can be thought of as a vacant atom site. It plays a part in lowering fracture strength and in determining the plastic properties of metals.

**Endurance limit.** Maximum stress a metal will withstand during a specified large number of cycles of stress.

**Face centered cubic lattice.** A unit cell in which all of the corners and the center of each face are occupied by atoms. Designated *fcc*.

**Free energy.** A measure of the energy of a system available to do work at constant temperature and pressure.

**Grain.** Synonymous with *crystal* when referring to pure metals or homogeneous solid solutions.

**Grain boundary fracture.** Failure where fracture path follows the grain boundaries and does not traverse the grains themselves. Usually a high temperature phenomenon.

**Isotropic.** Having physical and mechanical properties the same in all directions.

**Normal stress.** Stress developed by a load acting at right angles to a section and away from it.

**Shear fracture.** Failure along crystallographic planes that have greatest atomic density. Caused by shear stress.

**Shear stress.** Stress developed by a load acting parallel to a section.

**Stress concentration factor.** Ratio of the endurance limit of a plain test specimen to one containing the particular type of stress raiser under consideration.

**Twins.** A special form of slip that may occur in the plastic deformation of metals. In twinning, adjacent slip planes move in the same direction, each plane moving farther than the next one by a constant amount.


### Acknowledgments

The author would particularly like to thank Mr. E. L. Layland, Westinghouse Electric Corp. and Mr. P. P. Puzak, Naval Research Laboratory, for reviewing the manuscript. Mr. R. C. Bates, Westinghouse Electric Corp. furnished the information on fractography.

The assistance of the following is also greatly appreciated:

General Electric Co.
National Bureau of Standards
Naval Research Laboratory
Westinghouse Electric Corp.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The list of references above represents only a minute sampling of the voluminous literature relating to the problems of fracture. The reader is particularly directed to the following books: *Fracture*, John Wiley & Sons, '58; *Brittle Behavior of Engineering Structures*, John Wiley & Sons, '58; *Fracturing of Metals*, ASM, '48; *Fatigue and Fracture of Metals*, John Wiley & Sons, '52; *Stress Corrosion Cracking and Embrittlement*, John Wiley & Sons, '56; *Fatigue of Metals*, Philosophical Library, '53; *Defects and Failures of Metals* (Elsevier), Van Nostrand, '56.


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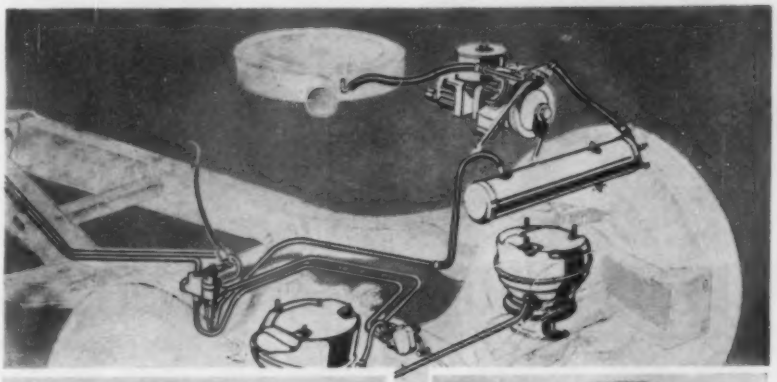

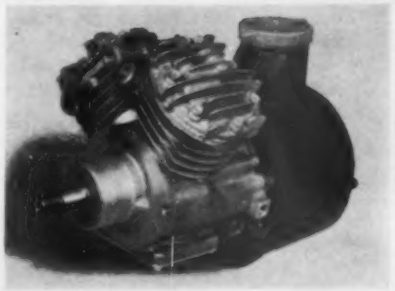

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**Retaining hot fluids or oils is easy . . . with seals made of Silastic®, the Dow Corning silicone rubber!**

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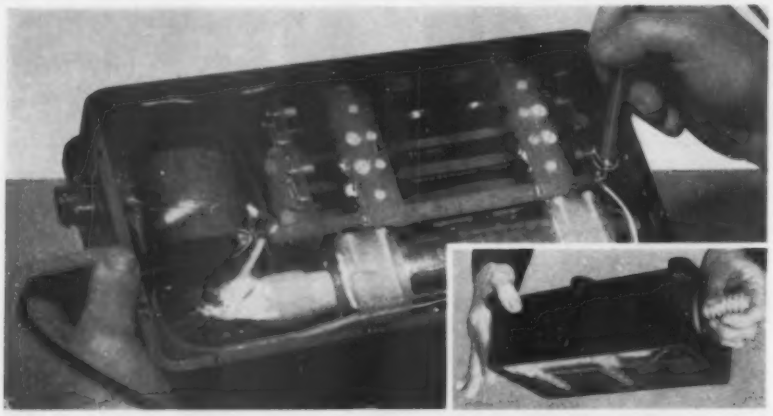
Silastic has earned its keep over and over as a gasketing and sealing material in the aircraft, automotive, appliance, electrical and process industries. You'll find it's profitable to consider Silastic whenever you have need of a flexible, durable sealing or gasketing material that must remain serviceable over a wide temperature span and in adverse environments. *No. 242*

**Effect of Heat Aging on Resiliency of Silastic and a Heat-Stable Organic Rubber**

| Temperature | Hours | Resiliency Silastic 50 | Resiliency Organic |
|---|---|---|---|
| 300 F | 0 | OK | OK |
| | 96 | OK | Broke |
| | 1344 | OK | — |
| | 6384 | OK | — |
| 392 F | 0 | OK | OK |
| | 19 | OK | Broke |
| | 1344 | OK | — |
| | 5040 | OK | — |
| 480 F | 0 | OK | OK |
| | 8 | OK | Broke |
| | 168 | OK | — |
| | 1344 | OK | — |

[1] As indicated by ability to take an 180 degree bend over 3/8" mandrel without breaking.



# NEW AID TO MINIATURIZATION

**New potting techniques developed by engineers at CBS Laboratories, a division of Columbia Broadcasting System, Inc., Stamford, Conn., capitalize on the properties of Dow Corning Dielectric Gel . . . result in substantial reductions in size and weight of airborne components of the "Photoscan" all electronic, visual reconnaissance system.**

Supplied as a fluid to facilitate filling and potting assemblies, Dielectric Gel sets up to a pliable, transparent gel of high dielectric strength, moisture resistance and thermal stability. The gelled mass exerts virtually no stress on components; has excellent adhesion; is not displaced if vibrated or inverted. CBS engineers found that Dow Corning Dielectric Gel supplied the many miniaturization and reliability advantages they sought for Photoscan's high voltage power supply.

Dielectric Gel reduces bulk by permitting high voltage components to be spaced less than ¼ inch apart without danger of arcing . . . enabled the power supply, capable of regulated voltage outputs of 1,000 and 25,000 volts, to meet stringent reliability requirements. It further reduced bulk by eliminating the elaborate bellows and seals necessary when using a liquid dielectric.

Other advantages: Dow Corning Dielectric Gel effectively cushions components against shock and vibration, permits instrument and visual checking of the power supplies, and greatly simplifies production and servicing . . . heals itself when probes are removed, leaves no voids. *No. 243*

**TYPICAL PROPERTIES OF CURED DIELECTRIC GEL**

| | | |
|---|---|---|
| Color | Water | White |
| Specific Gravity at 25 C | | 0.970 |
| Electric Strength*, volts per mil | | 800 |
| | 23 C | 150 C |
| Dielectric Constant 100 cps - 0.1 Mcs | 3.0 | 2.6 |
| Volume Resistivity†, ohm-cm. | $1 \times 10^{15}$ | $1 \times 10^{14}$ |

* 60 cycles, rapid rise, 0.020 inch-spacing of 0.5 inch-diameter spherical electrodes.

† Using 54 mmfd fixed air capacitor, Cardwell type, ER-50-FS as electrodes, ASTM D150-54T and D1169-52T.

## NEW ENGINEERING GUIDE

This recently published reference provides pertinent properties, data, and application information about the various silicones specified and used by design and production engineers in all fields. A comprehensive 16-page brochure includes concisely packaged information on silicone fluids, lubricants, resins, adhesives, varnishes, dielectrics, rubbers, water repellents, textile finishes, leather treatments, and other silicone products that offer practical solutions to a great variety of design problems. To obtain your copy, circle ..... *No. 244*

## new literature and technical data on silicones

**Tackles Many Insulation Jobs** — Today's electrical equipment requires insulation with endurance. A reprint from Power lists the many types of electrical equipment which perform better and last longer as a result of the use of silicone insulation . . . points up the benefits to be realized in industrial applications. *No. 245*

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**Effect of High Temperature and Nuclear Radiation** on Silicone Insulation Systems is detailed in an article reprint from Electrical Manufacturing. An intensive evaluation program on several silicone insulating systems has yielded realistic performance data that are presented in comprehensive, easy-to-study tables and graphs. A practical analysis of a thorough study. *No. 247*

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FILE FACTS

# Thickness of Cylindrical Shells Under Internal Pressure

These charts permit ready determination of the shell thickness of a cylindrical pressure vessel of a given diameter operating at a predetermined stress value and internal pressure. Wall thickness is obtained simply by: 1) following the cylinder diameter line up until it intersects the diagonal pressure line, and 2) extending a horizontal line left from the intersection until it meets the thickness scale.

In accordance with the latest changes in Section VIII of the ASME Unfired Pressure Vessel Code, the charts are based on three levels of welded joint efficiencies:

1. The 100% efficiency chart can be used for cylinders containing double welded butt longitudinal joints that are fully radiographed.
2. The 85% efficiency chart applies to cylinders with joints that are spot radiographed.
3. The 70% efficiency chart is for cylinders with joints that are not spot radiographed.

No increase in welded joint efficiency is allowed for a vessel where the welded joint is sectioned, or for vessels that are stress relieved.

Before using the charts, remember that a corrosion allowance must be added to radiographed steel vessels that are to contain air, steam or water. This is required by paragraph UCS 25 of the ASME Code.

All of the values were obtained by using the standard formula:

$$t = PR/(SE-0.6P)$$

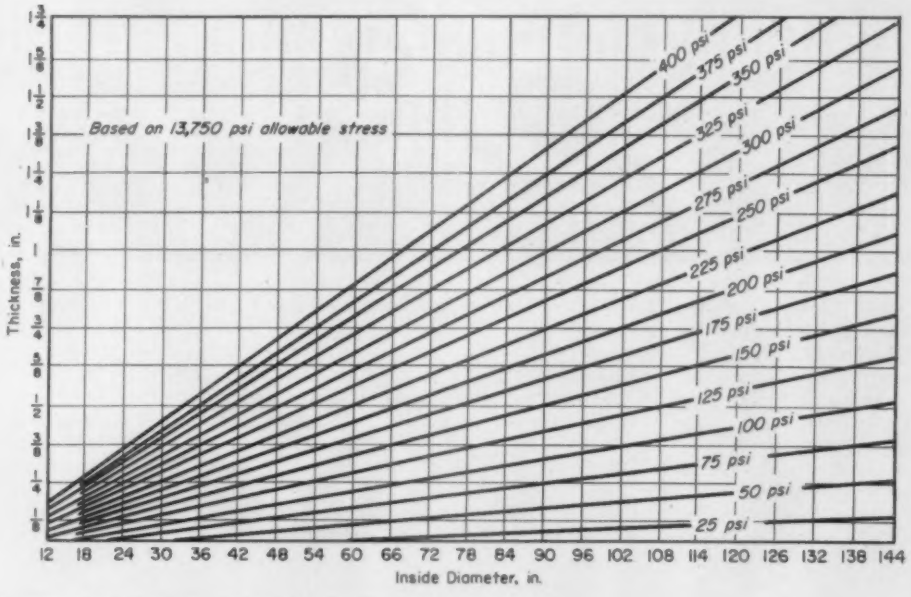
where t = thickness (in.), P = internal pressure (psi), S = allowable stress (psi), E = efficiency of joint (100, 85 or 70%), and R = inside radius (in.). An allowable stress of 13,750 psi was used in calculating all thicknesses. Thicknesses at higher or lower allowable stresses can be obtained by multiplying the thickness obtained at an allowable stress of 13,750 psi by the following constants:

| Allowable Stress, psi | Constant |
|---|---|
| 11,250 | 1.2220 |
| 12,500 | 1.1000 |
| 15,000 | 0.9167 |
| 16,250 | 0.8460 |
| 17,500 | 0.7857 |
| 18,750 | 0.7330 |

Thus, if a thickness of 1 in. is obtained at the given allowable stress of 13,750 psi, the new thickness at an allowable stress of 15,000 psi would be 1 in. x 0.9167 or 0.9167 in.

*These charts are reprinted from* The Unfired Pressure Vessel Code Simplified, *by Robert Chuse, Leonia, N. J.*

*Charts 2 and 3 appear on p 147*




**1—Wall thickness based on 100% joint efficiency**

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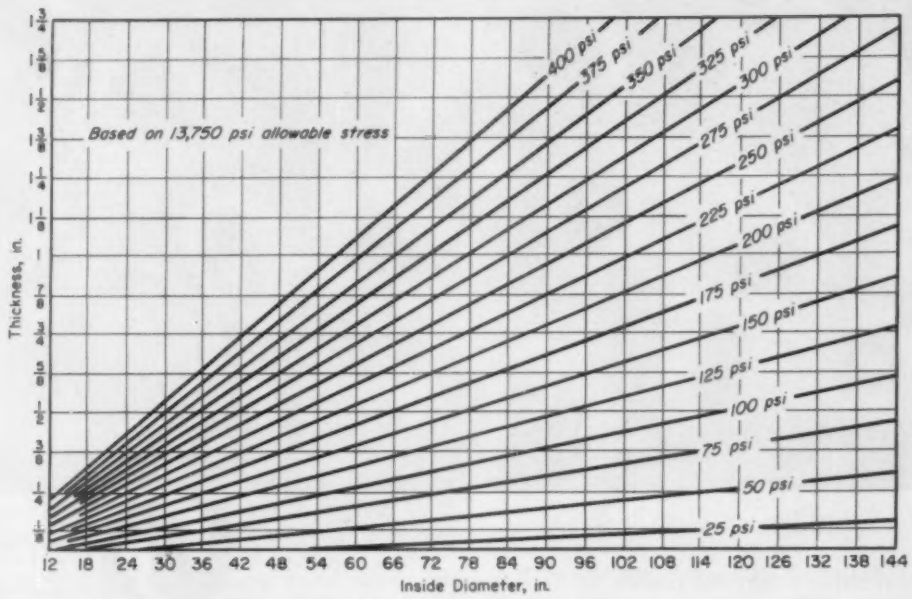
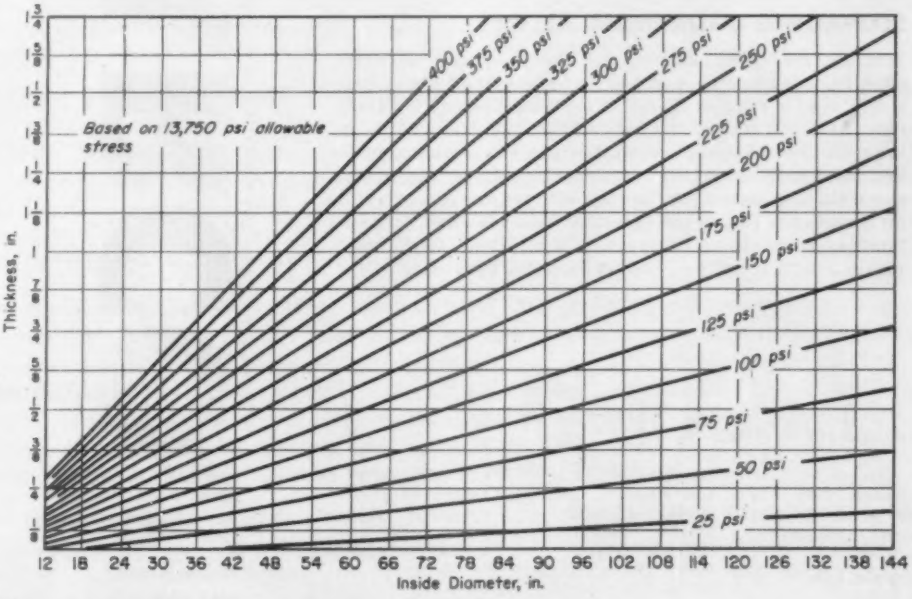
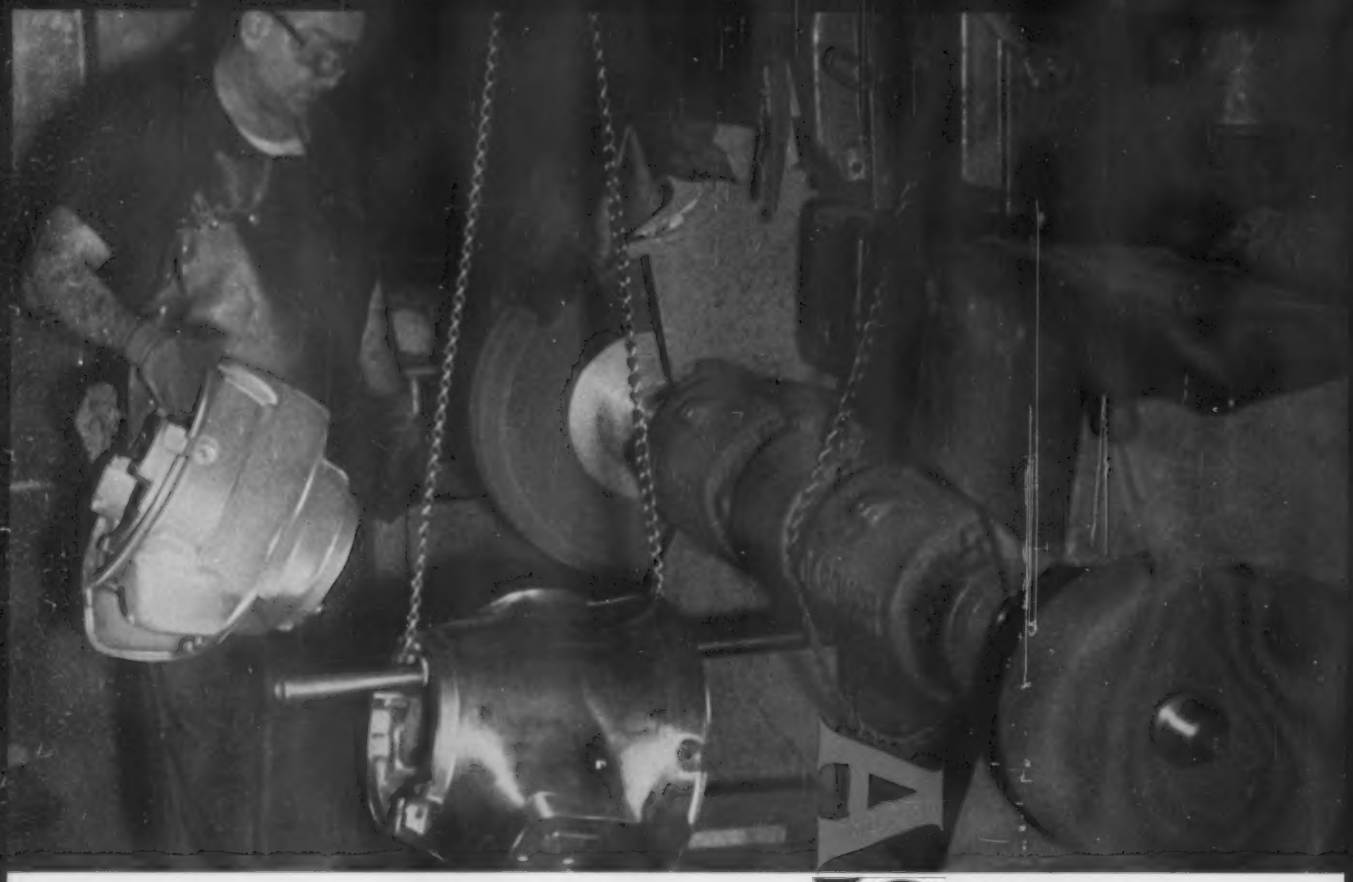
## Thickness of Cylindrical Shells (continued)




**2—Wall thickness based on 85% joint efficiency**




**3—Wall thickness based on 70% joint efficiency**



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# MATERIALS AT WORK

## ...AT A GLANCE

**Glass viewports have been specified for NASA's Mercury space capsules.** The "windows," which must enable the pilot to determine the vehicle's attitude as well as allow him to take astronomical photographs, must also withstand the extreme environmental stresses placed on the capsule's triple-layered metal walls. The windows consist of two outer panels of a 96% silica glass and two inner panels of heat resistant aluminosilicate. Air spaces between layers retard heat transfer.

Source: Corning Glass Works; space capsules manufactured by McDonnell Aircraft Corp.

**Remarkable weight reductions** have been made possible in the design of electronic filter "packages" used in missiles and satellites. Cores for the filters, now made from a magnetic molybdenum alloy powder compressed under high pressures and then annealed and finished, weigh only ⅓ oz as compared to 4¼ lb for previous units. Each package contains 23 filters which enable missiles or satellites to transmit such information as altitude, pressure, radiation, direction, etc. A typical telemetering system has been reduced from 207 lb to 11.1 oz.

Source: Arnold Engineering Co., Sub. of Allegheny Ludlum Steel Corp.; filters manufactured by Burnell Co., Inc.

**Urethane rubber impellers have been adopted for slurry pumps.** The pumps, required to move a slurry consisting of finely crushed rock particles, water and enough sulfuric acid to bring the pH of the solution down to about 1.8, previously used natural rubber impellers. However, these became so worn after pumping 250,000 tons of slurry that their metal frames became exposed to attack by the acid. The urethane impellers remained intact after pumping 778,500 tons of slurry.

Source: Du Pont; impellers molded by A-S-H Molded Products Co.; used by Faraday Uranium Mines.

**An aircraft carrier catapult structure** is now being made of two relatively new ultra high strength steels. The structures, which were redesigned to accommodate heavier, faster take-off planes, had to meet an end speed equivalent force of 6,850,000 lb, as compared to the previous 4,500,000 lb. Use of HY-80 (a higher nickel content version of AISI 4320) and a nickel-chromium-molybdenum steel casting not only provided the additional strength, but also cut weight by 6 tons (12%).

Source: Frederick Bennett, Puget Sound Naval Shipyard.

**A 2-in. layer of glass insulation has solved the problem** of maintaining rigid temperature controls on two huge liquid styrene storage tanks. Relatively constant temperatures are vital because liquid styrene (used in synthetic rubbers and many plastics) tends to solidify when cooled and polymerize when heated. The insulation, which consists of millions of tiny sealed glass cells, was applied to the 80-ft dia, 42-ft high tanks in 1955 and has thus far held up perfectly.

Source: Pittsburgh Corning Corp.; insulation used by General American Transportation Corp.

**Switch from brass to acetal plastic** has resulted in improved performance and a 60% cost reduction for parts used in the internal cartridge mechanism of a self-seating faucet. Use of acetal (Du Pont's new thermoplastic) is said to eliminate corrosion and/or deposits from hard water.

Source: E. I. du Pont de Nemours & Co. Inc.; faucet manufactured by Kel-Win Mfg. Co.

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# First Polyurethane Foam Radome

***Light weight of panels** permits easy erection. Panels are initially held by mechanical fasteners which are removed after polyurethane joint mortar has hardened.*

***Completed radome** has an equitorial diameter of 26½ ft and can withstand 200 to 300 mph winds.*

■ The world's first polyurethane foam radome has been erected at Ottawa by Canada's National Research Council. Designed for ground shelters requiring good dielectric "transparency" to minimize energy loss and boresight error in radar tracking installations, the radome consists of nine different shapes and sizes. Basic materials for the radome were supplied by Hooker Chemical Corp.; panels were molded by Long Sault Woodcraft Ltd. of Quebec.

The molder used an advanced technique, molding each panel with a nylon cloth outer skin. The skin surfaces are nonstructural and are designed to protect the panels against sharp impact. As further protection, a white weather-resistant coating was applied on the outside of the nylon cloth skin before the foam panels were molded.

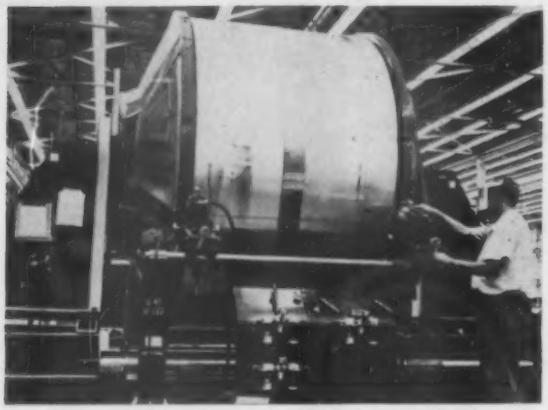
Density of the foam panels is only 6 lb per cu ft. Each panel is 3½ in. thick, with a dimensional tolerance of ± 1/16 in. The panels were bonded with a joint mortar made of polyurethane foam. Temporary U-shaped pin fasteners were hammered into pre-drilled holes to facilitate erection and to hold the panels in place. As soon as joint integrity was assured, the temporary pin fasteners were removed.

# Overhead Safety Guard of Expanded Metal

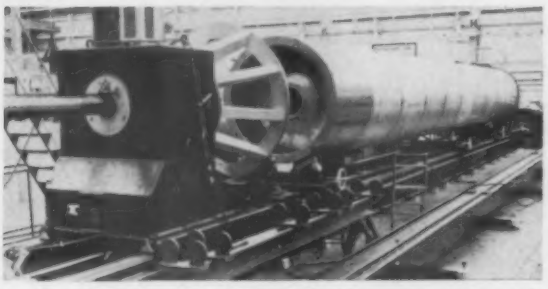
■ The overhead safety guard shown here is used to shield workers from a conveyor belt system carrying completed window frames. The diamond mesh pattern is formed by Trucson Div. of Republic Steel from solid plate of low carbon, open hearth steel. Advantages of expanded metal include: high strength, light weight, and good workability. It also permits penetration of light and circulation of air.

# The Saturn Space Vehicle:

## *eleven tons of aluminum sheet for initial booster*



*A 105-in. dia fuel tank, with skin formed from aluminum alloy 5456 sheet, will be surrounded by . . .*



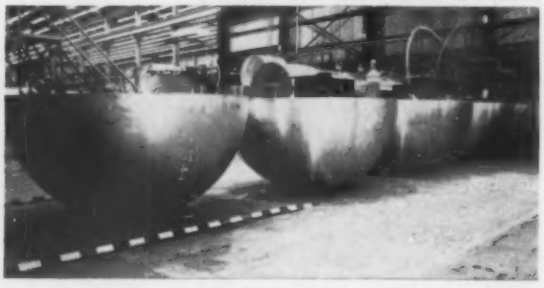
*. . . eight 70-in. dia fuel and liquid oxygen tanks with skins of the same aluminum alloy. In addition . . .*

■ The rocket engine of the Saturn, the first interplanetary space vehicle, will be capable of developing 1.5 million pounds of thrust. To accomplish this feat, eight H-1 liquid propulsion units are grouped and linked to fire simultaneously.

Much of the hundreds of tons of liquid oxygen required for these propulsion units will be carried in a Jupiter IRBM sheathed in aluminum alloy. Eight modified Redstone missile tanks, containing fuel and liquid oxygen, will encircle the Jupiter. The walls of these tanks are also aluminum alloy and form the outer skin of the entire booster unit.

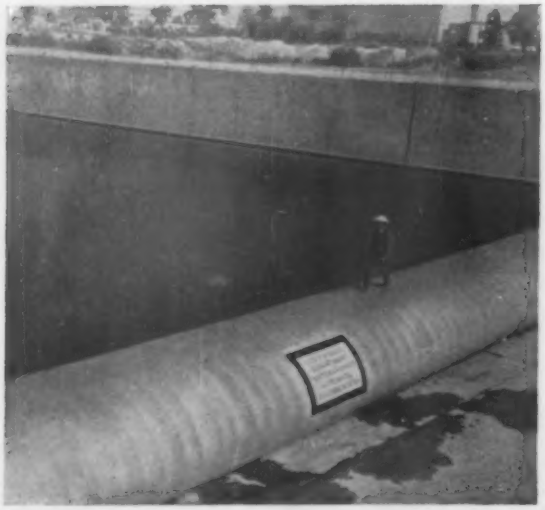
All of the aluminum alloy sheet used is type 5456. It was chosen because it is the strongest of the lightweight, highly weldable aluminum-magnesium series. In addition, alloy 5456 forgings are used to form weldable fittings and attachments.

Photos Aluminum Co. of America



*. . . five bulkheads spun from the same alloy will be welded into place in cylindrical tank sections.*

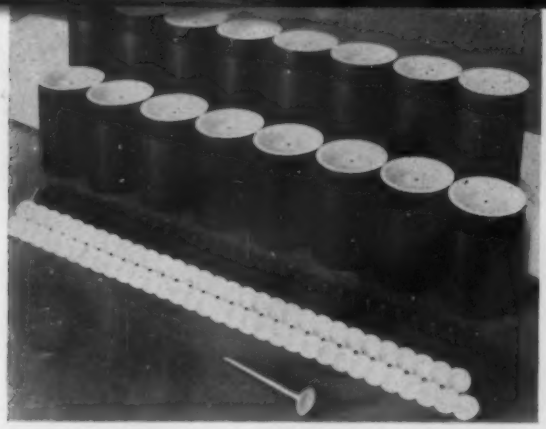
# Adjustable Dam Made of Nylon-Neoprene Fabric



■ This dam made of neoprene reinforced with nylon fabric is being used by the Los Angeles Dept. of Water and Power to solve a critical water conservation problem. The flexible tubular structure is inflated with water to a predetermined height. Through a siphoning arrangement it is gradually deflated as the weight of water flowing over it increases during flood stages. After the flood water subsides, the dam can be reinflated.

Nylon-reinforced neoprene was selected for the dam because it was tough enough to withstand abrasion from water-borne sand and rocks, and because it was flexible enough to collapse completely flat so that debris would not become entangled and form an impromtu dam.

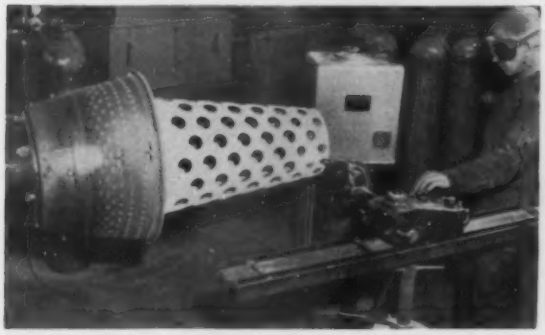
The tube was fabricated by lap splicing the ⅛-in. neoprene-coated fabric and cementing with a newly developed neoprene-base adhesive which cures at air temperature. As-inflated dimensions are 130 ft long (plus an additional 20 ft for slack and fastening) by 30 ft in circumference.



***Diesel engine parts** comprising 16 piston crowns, 64 valve heads and a cylinder head (not shown) are ceramic coated to reduce damaging effects of high temperature. Tests conducted by Chicago & Eastern Illinois Railroad prove that the coatings: 1) extend oil filter life from 8000 miles to 20,000 miles; 2) eliminate varnish deposits from piston skirts; 3) eliminate gummy deposits from cylinder liner air ports; 4) promote cleanliness of rings and ring grooves; and 5) provide important fuel savings.*

# New Applications for Flame Sprayed Ceramic Coatings

■ Ceramic coatings for the three uses shown are deposited by the Flame Ceramic process, developed by Armour Research Foundation and since acquired by Continental Coatings Corp. Ceramic particles are injected into a gaseous stream which is fed into a continuous flame generating device. Flame temperature and the time the particles spend in the flame are controlled to heat the particles to sintering temperature. The particles are then impinged on the surface to form a crystalline deposit with high adhesion.



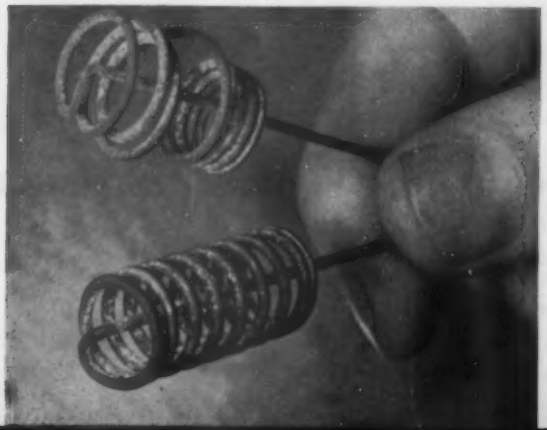
***Ramjet engine combustor** and inner cone assembly of Talos missile are ceramic coated to protect base metal at high temperatures. Tests show that coatings reduce temperatures at hottest areas by 400 F.*

***Furnace rolls** used in making silicon steel are ceramic coated to stop material pickup on rollers and thereby reduce dimpling of finished steel. In addition, users at Allegheny Ludlum Steel Corp. report that the coatings reduce the frequency of roller cleanings and shorten the time needed for cleaning.*

# Spring Reduces Brazing Problems at 1400 F

■ The NS-25 spring shown at left retains its shape after several hundred operations at 1400 F; the stainless steel spring next to it is deformed after one operation at 1100 F. The new spring is fabricated from NS-25 (Unitemp L605) and was developed by National Standard Co., Niles, Mich. to hold microwave components in jigs during a 1400 F brazing operation.

The ability of the NS-25 spring to hold its shape after many brazing operations allows it to replace weights, intricate fixtures or tack welding operations formerly used to hold components in place. Springs provide accurate positioning with a minimum of jigging time.



MORE MATERIALS AT WORK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Acrylic canisters ..... 164

Sunbeam die cast appliance part
North Amer. Philips nylon coil form
Dictaphone die cast circuit connector
Westinghouse insert molded insulating screw
TV tuner part
die cast instrument gear
Ronson die cast lighter part
die cast power tool part
Samsonite intercast hinged luggage closure
GM acetate car radio part
Carbide die cast flashlight part
Argus die cast camera part
Yale & Towne die cast lock part
Western Electric Delrin phone dial part
how many
of these
25 GRC
small parts ideas
can you use
in your business?
General Electric die cast timer part
Lionel die cast model train part
Remington Rand insert cast sensing brush
die cast mechanical pencil part
cast & molded control parts
IBM insert cast-mold commutator brush
Derecto die cast scale part
Cash Reg. adding machine part
Minneapolis-Honeywell die cast switch part
Ford Motor die cast horn part

Parts shown ½ actual size

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***TPR equipment** consists of a special recorder (top) and a modified movie projector (bottom).*

# Plastic Film Key to Recorder

A new recording system that is said to combine the ease and versatility of magnetic sound recording with the advantages of photographic reproduction has been developed by General Electric Co.

The system, which records pictures in either color or black-and-white on a plastic tape, does not require chemical processing, and is erasable and reusable. Moreover, it can concentrate 100 times more information in a given space than can magnetic recording.

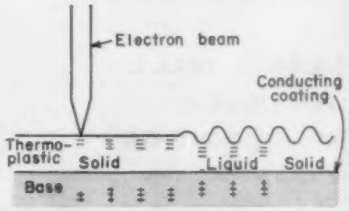
**Three-layer film**

The system, called thermoplastic recording (TPR), uses a specially prepared three-layer film. The film base, which is similar to standard moving picture film base, is covered with a transparent conducting coating which is in turn covered with a thin layer of a thermoplastic material (specific material undisclosed).

**Images form ripples**

When recording, the surface of the film is charged with an electron beam in a pattern that corresponds to the image to be recorded. As the film moves on, a current is induced in the transparent conducting coating which heats the film to the point where the outer thermoplastic coating starts to melt. The charges, that are attracted to the transparent conducting coating, depress the melting surface of the thermoplastic coating and form a ripple pattern. After the surface has been deformed by the charges, the film is cooled and the ripple pattern is "frozen" in place.

A simple modification of a standard movie projector allows the deformed film to be projected on a screen. To erase, the film is simply heated to a higher temperature,




***Schematic of TPR recorder.***

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*A designer for a leading electrical wiring device manufacturer hit upon a new design for a contact used in wall receptacles: eliminate the tie-down screws for incoming wire. Result—up to 30% saving in installation time . . . if a metal possessing the necessary properties could be found for the part.

The design called for a metal exerting just enough tension to lock the wire in place when inserted, keeping it from pulling out during installation and use. The headaches began when alloy after alloy fractured in forming the intricate part.

Then Miller entered the picture. Working closely with the manufacturer, Miller specialists were able to develop and supply a phosphor bronze alloy that entirely licked the fracture problem—and exhibited sufficient pressure to ensure good conductivity throughout a lifetime of service.

If savings in assembly and installation time, eliminating reject problems and cost-cutting from mill to finished part have a place in your operation, find out how Miller's experience in custom-tailoring phosphor bronze can save you time and money. *Name and case history on request.

miller SINCE 1888

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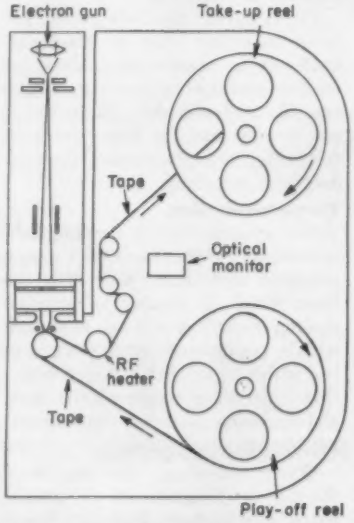
***Each frame** of the thermoplastic recording is less than ¼ in. wide and fits easily inside a paper clip.*

whereupon the charges leak away and surface tension smooths the film to its original state.

**Potential applications**

The new recording system is not yet commercially available. However, as an illustration of its unusual versatility, GE states that the TPR system could record all 24 volumes of the Encyclopedia Britannica on a reel the size of a spool of thread—and do it in less than half an hour. The most promising applications, therefore, are those which require a great deal of information




***Basic mechanism of TPR.***

# Tool Steel Topics

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

## Inserts of Brake Die Tool Steel form runners for oven wrappers

The sheet-steel part above is an oven "wrapper" for a gas range, produced by Calorie Appliance Corp., Topton, Pa. The wrapper has deep side-member runners on opposite sides. These were formed by inserts of Bethlehem Brake Die in the tool steel forming die at the right of the photograph.

Calorie's engineers reported fine results with Brake Die because of its durability. It also proved economical, as it saved time during machining. Used in duplicate sets of three, the inserts formed 22-gage steel to the tune of some 4,000 pieces before polishing became necessary.

Bethlehem Brake Die is ideal for intricate bending and forming applications because of its fine wear resistance, high toughness, and exceptional resistance to impact. It saves money, because it comes in the heat-treated condition, ready for machining without further hardening. We not only quench and temper Brake Die to develop its superior properties—we also straighten it mechanically. This is followed by a stress-relief-anneal, then gag straightening.

Give Brake Die a trial. But don't baby it—choose a tough job. The nearest Bethlehem tool steel distributor will be pleased to work with you.

---

Because of its high vanadium content, Bethlehem Cromo-High V is ideal for die casting aluminum- and magnesium-base alloys in the 1200F-1300F range.

Cromo-High V has outstanding machinability because it comes in the annealed condition (Brinell 207). It has excellent resistance to the formation of a fine network pattern of heat checking. In heat-treatment, it develops the uniform hardness needed to resist wash and erosion.

## BETHLEHEM TOOL STEEL ENGINEER SAYS:

### Bake Tools After Plating

There are three reasons why tools are electroplated with chromium or nickel: (1) salvage, by regaining worn dimensions, or correcting mechanical errors (2) decoration (3) to resist wear or metal pickup.

Although electroplating of hardened tools is relatively simple, it can be hazardous if the plating is not followed by baking (tempering). During deposition of the plated metal, a considerable amount of hydrogen also is deposited on the tool. Some of this hydrogen diffuses into the tool. This causes extreme brittleness, so that if the tool is used immediately after plating, breakage in service may occur.

To avoid such an occurrence, bake the tool at 300-400F for at least four hours, to restore its original ductility. Baking should begin as soon as possible after plating. Grinding should never be done on the steel itself prior to baking. If baking is omitted, the tool will gradually recover its ductility at room temperature in from two to three weeks. It will be subject to breakage if used before the recovery has been completed.

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to be recorded quickly and accurately in the least possible space.

Other possible areas of use include: radar, radar jamming, missile guidance, aerial reconnaissance and data-transmitting satellites.

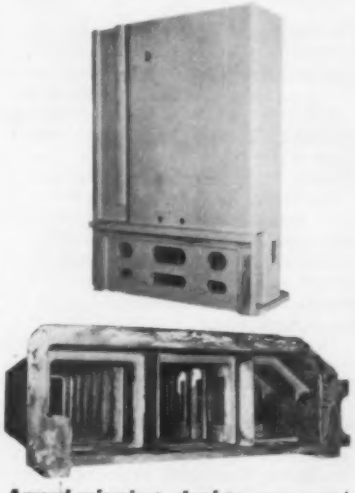
## Gray Iron Castings Cut Costs of Planer

The use of gray iron castings instead of weldments has resulted in a saving of almost $3000 in the design of right and left hand columns for a double housing planer.

The design, submitted by J. T. Eccles and D. H. Davis of Rockford Machine Tool Co., was awarded first prize in the recent design contest sponsored by the Gray Iron Founders' Society.

Original plans called for the columns to be made from welded steel. However, the design presented several problems: 1) internal horizontal ribbing was not possible in the required 12-in. increments; 2) doubt as to whether the weldments would have the required rigidity, damping effects and strength; 3) difficulty of holding tolerances; and 4) excessive costs.

By turning to gray iron castings, the ribbing was easily obtained, costs were cut substantially, machin-



***Award-winning design*** *uses cast planer columns (here shown vertical and as the interior appears from the bottom).*

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ing time was reduced by 50%, and the finished planer easily met Machine Tool Builders' Assn. tolerances as a result of the rigidity inherent in gray iron castings.

## Silver Solder Solves Corrosion Problem

The switch from conventional mechanical fasteners to a silver-bearing stainless steel solder has solved a plating racks.

The problem: to eliminate damaging electrolytic action which occurcorrosion problem in the design of red through tears in the plastic-coated racks at points where the copper contacts are bolted to the frame (see accompanying photo)

Solution 1: Nuts and bolts were eliminated by brazing the contacts to the frame. However, this created another problem: the heat of brazing annealed the copper contacts and they bent under load.

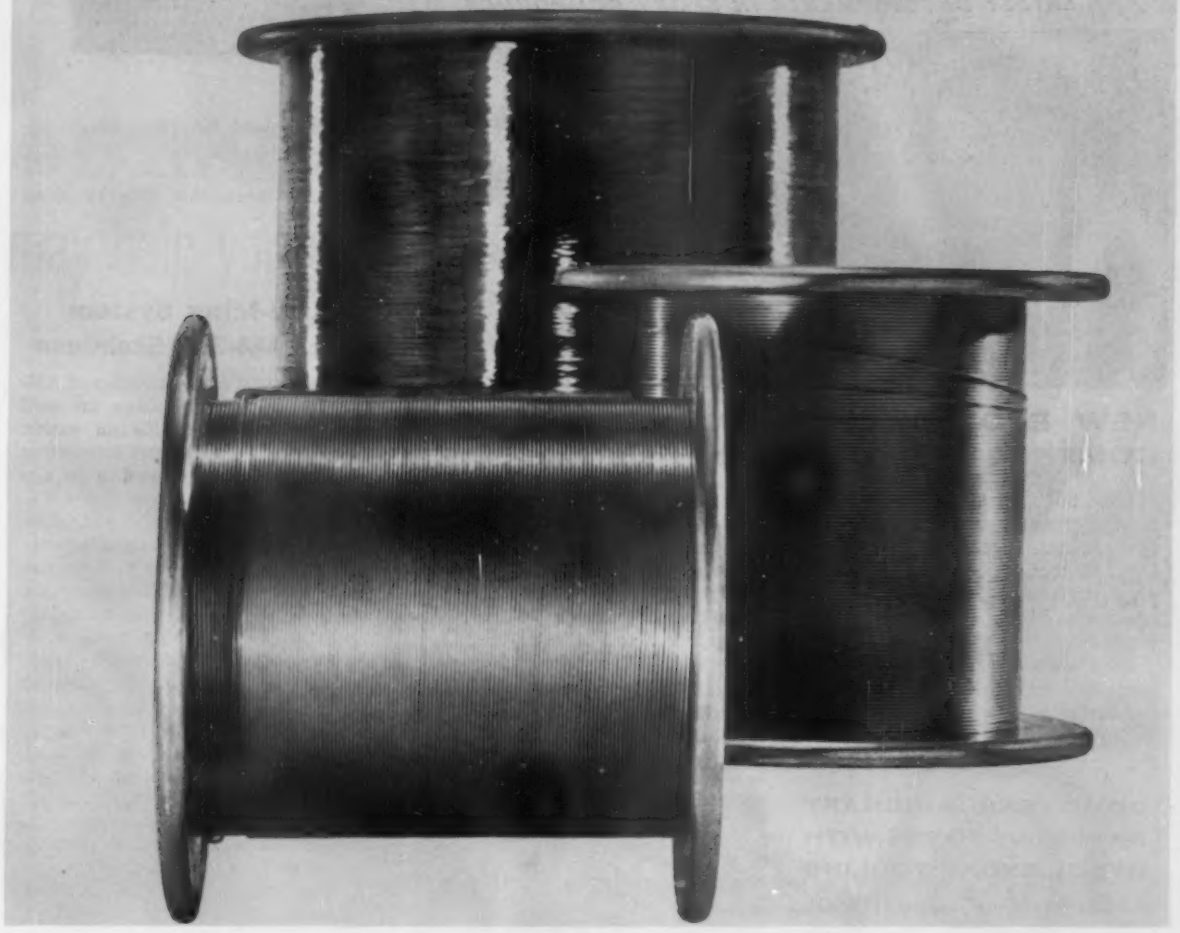
Solution 2: Nuts and bolts were replaced by soldering. However, the conventional hard solder used, which required a temperature of about 1100 F, also had an annealing effect on the copper.

Solution 3: Select a solder whose melting point was below the annealing temperature of copper, yet above 365 F, the temperature at which the polyvinyl chloride coating is baked onto the rack. The answer was a high strength (tensile strength is 28,000 psi), silver-bearing stainless solder and a non-acid flux with a working temperature of 430 F.

According to All-State Welding Alloys Co., producer of the solder, the switch saved North West Plat-

***Soldered contacts** (left) outlast bolted contacts (right).*

SYLVANIA MAKES ALL THREE—ALLOY, CLAD AND PLATED WIRE



# How to speed up design of new products

## —call Sylvania for an unprejudiced recommendation on wire

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Result? Your Sylvania wire recommendation is unbiased. It's based on *your* design's needs and is not restricted by a limited line. You can get full details for future use—or timesaving help on your present project—by writing Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.

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VOLUME 1 NUMBER 1

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## NEW EPOXY MOLDING COMPOUND FOR COMPRESSION OR TRANSFER MOLDING

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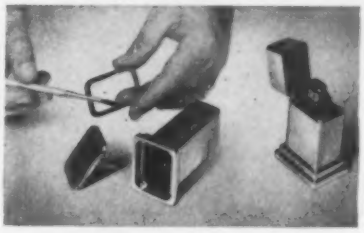
Here are a few of the outstanding properties of HYSOL 8610: good flow for insert molding; low shrinkage during cure; excellent dimensional stability, less than 0.15% change after 400 hours at elevated temperatures; excellent electrical properties over a wide range of temperatures; fast cure — 60 seconds to 5 minutes depending on thickness; minimum of one year storage life at room temperature.

For complete information on this remarkable new molding powder write for Bulletin 8610.

## GOODYEAR AIRCRAFT SAVES 50% TO 75% WITH HYSOL EPOXY TOOLING

By forming aluminum to HYSOL Epoxy tooling dies, Goodyear Aircraft slashes tooling costs up to 75%. Because HYSOL Epoxy tools can be cast or laid up directly from the master mold without hand barbering or fitting, skilled labor time is cut to a minimum and costly machinery is eliminated. Combined with the low cost of HYSOL Epoxy Tooling Materials, manufacturers across the country are making almost unbelievable savings.

For complete information on how you can make similar savings write for Bulletins T21A and T22A.



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HYSOL (CANADA) LTD.
Toronto, Ontario

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ing Co. about $25 per rack. In addition, soldering reduced the weight of the racks, increased their life, and cut fabrication time by about 80%.

## Jet De-Icing System Uses AM-350 Stainless

The special characteristics of AM-350 stainless steel tubing are said to have made possible an easier, more efficient method of fabricating the 100 ft of tubing used in jet aircraft anti-icing systems.

According to Allegheny Ludlum Steel Corp., elbows and joints previously used to connect the complex tubing were made as drop hammered halves which were welded together and then to the tubing.

Use of "highly formable" AM-350 eliminates the need for separate elbows and joints because the tubing itself can be bent to the desired shape. Flanges can also be made integral with the tubing, thus providing a stronger, safer system. In addition, the steel's high strength-weight ratio at elevated temperatures permits minimum weight.

The tubing, used on Lockheed Electras, is supplied in the dead-soft annealed condition. After fabrication, the tubing is process annealed and then precipitation hardened at sub-zero temperatures to provide maximum strength and hardness.

Specifications call for the ducting

***Complex configurations** are easily achieved with age hardenable AM-350 stainless tubing.*

**ARMCO STEELS** / for better products • lower costs

New steels are born at Armco

# ARMCO ZINCGRIP STEEL

## may help you cut costs of parts that must be durable

**Production forming and laboratory tests demonstrate that the special hot-dip coating on Armco ZINCGRIP won't flake or peel.**

Drawing, forming, piercing and interlocking operations don't impair the protective value of this ZINCGRIP part.

This tensile test specimen shows that right up to the fracture, where the metal stretches 60-70%, the coating on ZINCGRIP stays on.

These photographs show how far ZINCGRIP can be stretched and formed without damaging its tightly adherent mill-applied zinc coating. For the past 25 years this performance has been demonstrated in plants making a wide range of parts from ZINCGRIP.

This special Armco Steel enables you to give parts the economical lasting protection of a uniform, full-weight zinc coating. For example, parts you are now plating or painting may be made of ZINCGRIP at much lower cost. For only a few cents' premium over cold-rolled steel, ZINCGRIP creates the possibility of eliminating not only plating or painting but the necessary cleaning and inspection those operations entail.

Because you can put this special Armco Steel through regular production lines without damaging the protective zinc coating, manufacturing costs are low. Let us send you complete information on Armco ZINCGRIP Steel so you can evaluate its advantages for your products. Write Armco Steel Corporation, 1470 Curtis Street, Middletown, Ohio.

# ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

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Discharge Valve

# SWITCH FROM SAND CASTINGS TO BRASS FORGED PARTS

**Here's why!** Your component parts forged of Titan brass will outperform any you now buy as sand castings. No more costly rejects due to blow holes and sand inclusions. Eliminate leakage and other product failures. The twice-wrought metal in brass forgings has the inner toughness and density to give you new strength and workability. Thinner sections can be used.

**Tensile strength** is almost double that of most sand castings. Closer tolerances, dimensional uniformity of production lots, and superior finish unknown in sand castings are routine in Titan forgings. For you this means faster chucking and better machinability—threads can often be chased on the forging without preliminary forming. And you have less scrap and less finishing cost prior to plating.

**In a Titan forged part** you get greater eye appeal to help sell your product. Look at the smooth surface of these forgings to see what we mean; each was once a rough sand-cast part.

May we say more? Call your nearest Titan office for detailed information and a brass forging quote on your sand-cast parts.

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DIVISION OF CERRO DE PASCO CORPORATION

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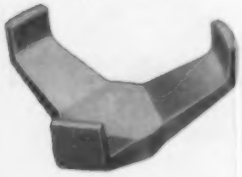
Main Valve Control

Heat Exchanger Head

Gauge Socket

Air Compressor Part



Storm Door Handle

Main Valve Seat

Lavatory Pop-up Plug






to withstand temperatures up to about 700 F and pressures up to about 200 psi. Gage ranges from 0.025 to 0.187 in., o.d. from 1⅛ to 4½ in.

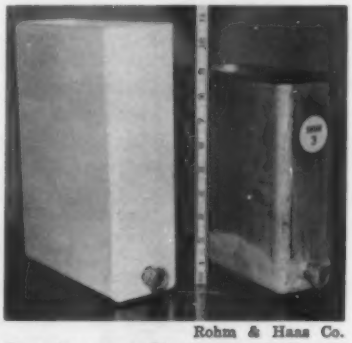
## Acrylic Canisters Better than Stainless

The change from stainless steel to high impact, modified acrylic has resulted in increased capacity and reduced cost for canisters used in beverage vending machines.

The canisters are used to dispense powdered coffee, sugar, cream and chocolate into a hot water mixing chamber. According to Bert Mills Corp., the previous canisters were made of 304 stainless, measured 9 x 9 x 3 in., and were drawn from flat blanks to a final wall thickness of 1/32 in. in a series of six draws with an annealing step between each draw.

When the drawing dies became worn, the possibility of using molded plastics was investigated. Melamine and acrylic were considered; acrylic was specified because it provided the necessary physical properties at about half the cost.

In addition to reduced costs (delivered price of the acrylic canister is about one-fourth that of the stainless canister) and greater capacity (about 20% more), the acrylic canisters provide these advantages: excellent dimensional stability, low moisture absorption, good surface toughness, high impact resistance and, especially, excellent stain resistance.



Rohm & Haas Co.

***Greater capacity** is one of the advantages offered by acrylic canisters.*

**Experience**—*the added alloy in* **Allegheny Stainless**

# Sample pages from A-L's new free booklet on design

"Design and Allegheny Stainless" is illustrated page after page with hand-picked examples of good design in the gleaming metal.

Twenty-four photographs and drawings in full color, twenty-six in dual color and black and white become a showcase of the versatility of stainless.

The examples are presented with text in terms of Function, Shape, Texture and Color. They cover many fields from automotive parts to holloware for the home . . . to open new horizons for the designer.

There is a working outline of types and properties in the many grades of Allegheny Stainless. Some of the new textures illustrated will interest the designer looking for new effects.

Write for your copy of "Design in Allegheny Stainless Steel"—without cost or obligation. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. MI-4.*

Packed with actual examples of good design—and ideas for future applications

**ALLEGHENY LUDLUM**

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

994

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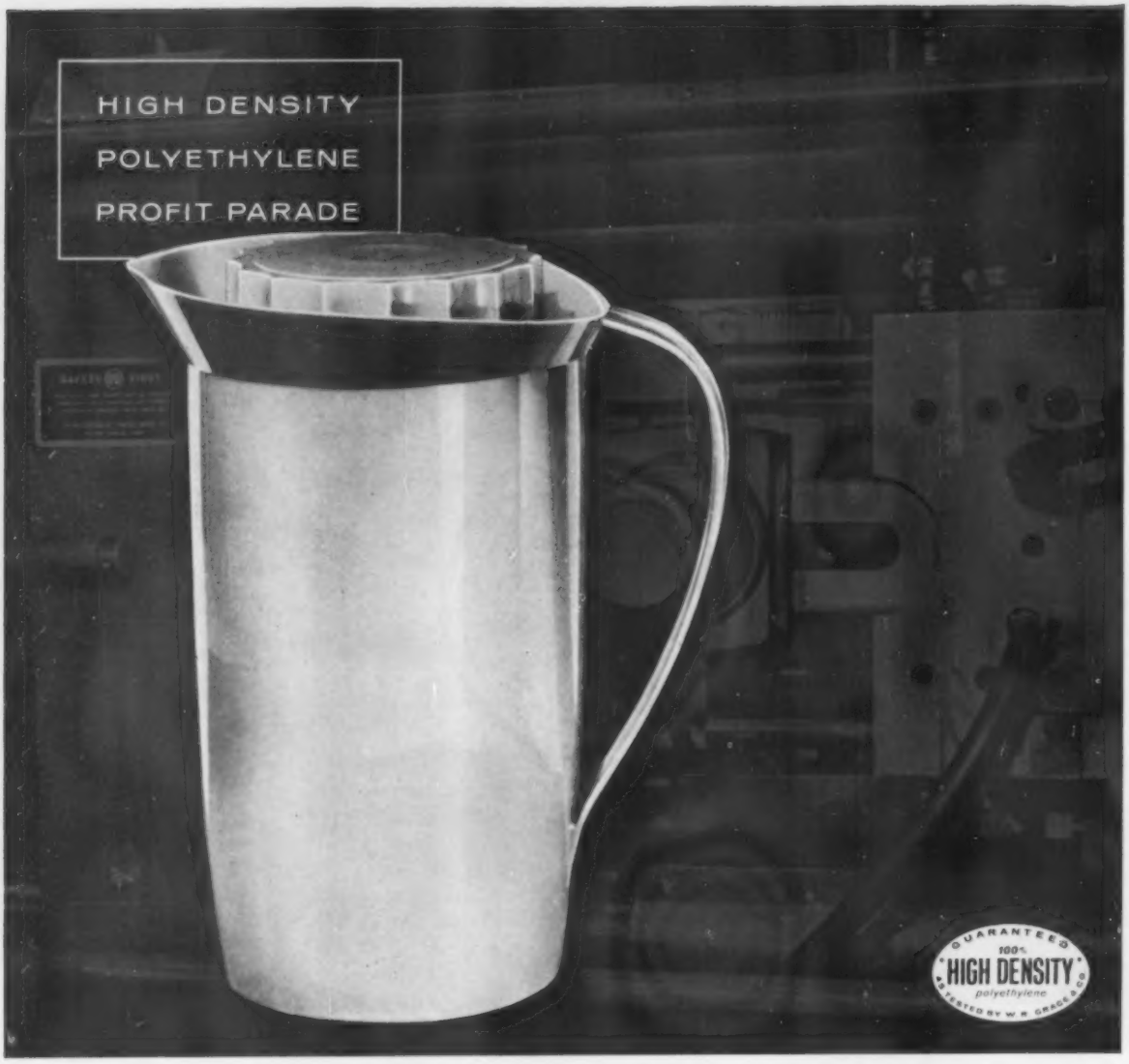



# Grace Helps Expand a Housewares Line

If you have an idea for a new product that lends itself to high density polyethylene—but haven't done much more than preliminary thinking—now is the best time to call Grace in for help. Plastray Corporation can tell you this philosophy really pays off.

An established manufacturer of plastic housewares, Plastray wanted to expand its line with a new pitcher which they had designed and that would take full advantage of the profit-building properties of Grex high density polyethylene. Grace was brought into the picture from the beginning to help in the design and construction of Plastray's molds, and produce the first samples in the Clifton laboratories in time for the manufacturer to write orders at important trade conventions.

The finished product offers almost every feature that housewives look for in a pitcher. It is big enough to hold over two quarts, yet remains rigid and strong. It withstands the lowest refrigerator temperatures without losing its strength, and boiling water without losing its shape. Colors are permanently molded in. Chemicals often harmful to pitchers made of other materials cannot mar, stain or soften its attractive glossy finish.

Naturally, we are pleased to have played a major role in its development—and would like to help put your product in the Grex profit parade, too. Grace has the resin production facilities, technical service and experience you need. Everyone says we're easy to do business with.

*Grex is the trademark for W. R. Grace & Co.'s Polyolefins.*

**W.R. GRACE & CO.**
**POLYMER CHEMICALS DIVISION** CLIFTON, NEW JERSEY

**For more information, turn to Reader Service card, circle No. 460**

Pitcher reflects valid principles in designing for Grex.

Chances are you will never design a pitcher in high density polyethylene. Yet an understanding of the design characteristics of this particular pitcher may help you do a better job on applications for Grex in your own field.

*Strength is needed.* One of the major requirements for the pitcher centered on the fact that a full 70-ounce capacity was wanted. The need for strength and rigidity naturally followed. It is an interesting comment on the design itself and the physical properties of Grex that these requirements were met by generating a compound curve and using thin wall sections.

*Use of thinner walls* in any design for high density polyethylene results in production economies just as it did in this case. Fast molding cycles were achieved and material was saved. This is made possible by the outstanding physical properties of the material used. Variations in wall thickness and heavy sections were avoided in the pitcher design as a precaution against warpage, shrinkage and points of stress concentration.

*Surface finish.* A high gloss on the outer surface and pouring lip of the pitcher was desired for eye appeal. This was obtained by using a highly polished chrome-plated mold. The inner surface of the pitcher has a matte finish due to the fact that the mold's core is vapor honed to prevent sticking or freeze-up when ejecting the part. Practically any finish is possible in designing for Grex.

*Call us for help.* The pitcher story is a good example of the type of service we are ready and willing to provide you. If you are working on a design that calls for high density polyethylene —or are just in the thinking stage—now is the time to contact:

Technical Service Department
W. R. Grace & Co., Clifton, N. J.

# ENGINEERING & DESIGN

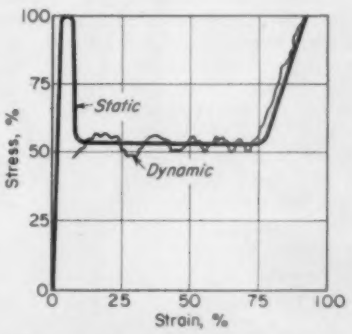
*Honeycomb—continued from p 126*

to the exterior of the inner walls of the reactor, these cooling walls act as a conductor medium to transmit heat and energy into the flow region of a suitable fluid that will carry off heat. In this application, welded stainless steel honeycomb was chosen because of its resistance to corrosion and its good high temperature properties.

**Shock absorber**

Aluminum honeycomb is used as a highly effective mechanical energy absorber. Most energy absorbing materials and devices have one common disadvantage; they do not absorb energy at a constant rate. For example, bulk filler material used in shipping crates to absorb shocks in handling or dropping has a nonlinear shock absorbing characteristic. As the material crushes under load, it absorbs energy at an ever increasing rate, like a spring with an increasing spring constant.

Honeycomb shock absorbers collapse at a near linear rate (see Fig 4). After determining the maximum "G" load to which an object can be exposed, a honeycomb shock absorber is designed to prevent this "G" load from being exceeded. The object is then brought to rest in almost the minimum possible time.




***Honeycomb materials** have a near linear collapsing rate under load.*
(Hexcel, Inc.)

**Electromagnetic shielding**

In the testing of radio and other electromagnetic wave transmission equipment, honeycomb has provided a variable shielding screen that prevents the escape of energy to other test areas, and at the same time allows maximum ventilation. It is common to use a number of layers of copper window screen for such shielding. However, this type of shield is difficult to see through and usually causes considerable obstruction to the flow of ventilating air to those areas in which a large amount of heat is generated. The honeycomb shield allows the core to function as a structural panel in areas which also require loading, such as equipment attachment.

**Diffusers**

The light directional property, or the ability to direct light paths, of honeycomb has been utilized in various ways. For example, when light-colored honeycomb layers are placed in front of an indoor light source, such as a fluorescent tube, the light is diffused to such a degree that shadows are almost eliminated and a general evenness of ambient light is achieved. This effect has proved especially valuable in improving TV reception, and in reading of test data where closed circuit TV is used to monitor data in industrial and test setups.

**Other applications**

Some of the unusual engineering applications of honeycomb now being investigated include radiation shielding, catalyst support, wind tunnel flow straighteners, ceramic support, and jet engine noise suppressors.

Lead honeycomb is used in nuclear reactor power plants as a directional shield for radiation. Here, the radiation path is directed by the honeycomb cells. The degree of direction is determined by the cell length and cell diameter.

As a catalyst support, a stainless

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Blend your imagination with McDanel specially developed alumina ceramics. If high temperature, abrasion, corrosion, chemical action, or other deteriorating factors are present in your project, then McDanel alumina ceramics could be your answer. Instrument manufacturers, scientists, physicists, research and development engineers, and specialized producers have found that McDanel custom-produced, alumina ceramics can be applied to a wide variety of difficult applications with excellent success. So, if you are faced with a tough materials problem, see what McDanel alumina ceramics can do when you mix your imagination and engineering with McDanel experience and craftsmanship. McDanel ceramic engineers are eager to work with you. Try ceramics! Call McDanel!

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steel superalloy honeycomb is coated with a very thin coating of a suitable catalyst and placed in the combustion zone of an exhaust system of an industrial furnace. In this case, the large surface area and low resistance to flow are decided advantages of the honeycomb construction.

In straightening air flow in a wind tunnel, the air directional properties of honeycomb are an obvious advantage. Honeycomb properly placed in a wind tunnel is expected to permit raising wind tunnel velocities with a decided decrease in turbulence.

The continuing "rediscovery" of metallic honeycomb in unrelated engineering fields indicates the growing usefulness and adaptability of this engineering material. From the wide variety of fields in which metallic honeycombs have already been applied in the last few years, it seems clear that the potential uses of this form of material have only begun to be realized. As new alloys are produced in foil form and new core-to-face attachments are developed, potential uses will continue to multiply.

## Vibration Damper for Electronic Equipment

Electronic equipment in missiles can be protected against vibration and shock by using a multi-layer grid of TFE rods embedded in a matrix of silicone rubber (see accompanying sketch). Principal feature of the new vibration damping material is its high internal damping produced by friction at the TFE-silicone rubber interfaces.

Vibration transmissibility tests performed by Robert H. Jacobson of Armour Research Foundation show the material has a maximum transmissibility value of 2.1, compared to a value of 5.0 specified in the current military specification for vibration mounts (Mil-C-172B). The vibration transmissibility value of the new damping material is also said to be much lower than transmissibility values for rubber-like materials currently being used in missiles for protecting gyro equipment.

The TFE-silicone rubber material withstands temperatures from –85

# HONEYCOMB
and
**sandwich panel**
FASCO
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PATENT PENDING
by Delron

**STRUCTURAL FASTENER**
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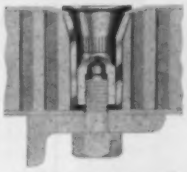
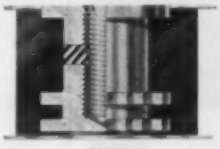
Thru-rivet and Bolt Type

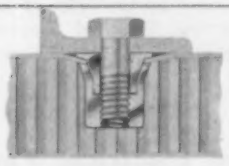


**STRUCTURAL FASTENER**
Series 603
Series 604 (Self-Locking)
Internal Thread
Structural Blind Type

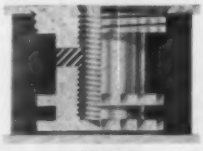
**STRUCTURAL FASTENER**
Series 700
Floating Locknut Type



**BLIND NON-STRUCTURAL FASTENER**
Series 404H
Blind Potted Type

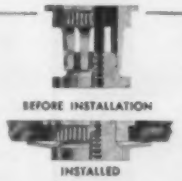


**BLIND NON-STRUCTURAL**
Series 293
Internal Thread Blind Type



**BLIND NON-STRUCTURAL FASTENER**
Series 404G
Blind Potted Type

**NON-STRUCTURAL FASTENER**
Series 101 and 102
Thru-rivet and Bolt Type




**BLIND NON-STRUCTURAL FASTENER**
Series 293K
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● *Write for complete Technical Data*

**NON-STRUCTURAL FASTENER**
Series 103
Series 104 (Self-Locking)

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And because Fasson Mylar* Vinyl Laminates are self-adhesive, they cut application costs, often quite drastically. Applied merely by peeling off the protective backing paper, pressing into place. No drilling, no fasteners, no special tools or skills are required. For simple, straight-run trims, it can be supplied in narrow rolls, sheets or strips to your order.

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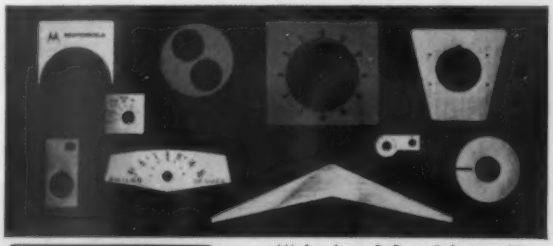
**Fasson Mylar* Vinyl Laminates can be die cut in almost any design or shape.**



*Mylar is a DuPont Polyester Film

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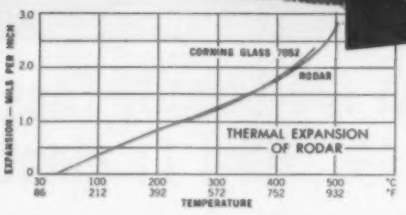


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This precision alloy was developed for sealing metal to hard glass. Wilbur B. Driver Rodar is processed from melting to finished size in our own plant under the strictest controls to insure consistent analysis, temper, uniform grain size and conformance to customers' specifications. The superior stamping and sealing properties of Rodar make it *the preferred sealing alloy.*

Rodar produces a permanent, vacuum-tight seal with simple oxidation procedure and resists attack by mercury. Readily machined and fabricated, Rodar can be welded, soldered or brazed. Available in wire, strip and bar to your specifications.

**PROPERTIES**

Composition (Nominal)
Nickel . . . . . 29%
Cobalt . . . . . 17%
Manganese . . .30%
Iron . . . . . Balance

Melting Point
. . 1450°C. (Approx.)

Specific Gravity . . 8.36

Weight Per Cubic Inch
. . . . . .302 lb.

Electrical Resistivity
. . . 294 Ohms C.M.F.

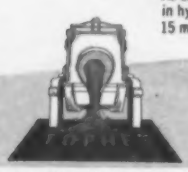
Tensile Strength
. . . . . 80,000 PSI

Hardness
. . . . 82 B Rockwell

Elongation
30% (2" gauge length)

| Temperature Range | Average Thermal Expansion, °Cm/Cm/°Cx10-6 |
|---|---|
| 30° To 200 C. | 4.33 To 5.30 |
| 30° To 300 C. | 4.41 To 5.17 |
| 30° To 400 C. | 4.54 To 5.08 |
| 30° To 450 C. | 5.03 To 5.37 |
| 30° To 500 C. | 5.71 To 6.21 |

*As determined from cooling curves, after annealing in hydrogen for one hour at 900°C. and for 15 minutes at 1100°C.



WILBUR B. DRIVER CO.
NEWARK 4, NEW JERSEY

IN CANADA: Canadian Wilbur B. Driver Company, Ltd., 50 Ronson Drive, Rexdale (Toronto)

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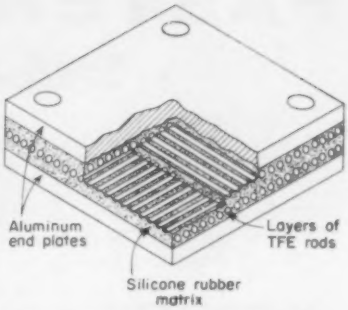
ENGINEERING & DESIGN




***TFE-silicone rubber material*** *protects electronic equipment against shock and vibration.*

to 482 F. It has good resistance to humidity, salt spray, fungus, combustion and pressure, and has long storage life.

Details of Jacobson's work on the TFE-silicone rubber damping material may be found in Report No. PB 151005, issued by the Office of Technical Services, Dept. of Commerce, Washington 25, D. C. The report sells for $2.75.

## Sealed Electrical Parts Insulated with Alumina

A basically new approach for protecting electronic components against moisture and heat was revealed recently by L. W. Kirkwood and R. S. Key of Bell Telephone Laboratories, 463 West St., New York 14. They described how powdered alumina (aluminum oxide) can be used successfully to insulate transformers and other electrical components within hermetically sealed cans.

A paper describing the development was presented at the National Conference on Application of Electrical Insulation, held last December in Washington, D. C.

### Alumina may replace conventional potting compounds

The researchers say alumina powder has a good chance of replacing asphalts, epoxy resins and other conventionally used potting compounds for three reasons:

1. Alumina powder has a melting point (2700 F) well above the operating temperature of any elec-

**Stainless steel**

**takes all kinds of punishment!** There's almost no day-to-day abuse that stainless steel can't take! It doesn't peel . . . it stands up to denting, scratching, heat and corrosion, and still retains its deep-down beauty. No other commercially available metal offers so much . . . to everyone. And the very best stainless steels are made with Vancoram Ferroalloys. Vanadium Corporation of America, 420 Lexington Avenue, New York 17, N. Y. • Chicago • Cleveland • Detroit • Pittsburgh

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....Why Metals Break; What to Do About It

....Guide to Materials Standards & Specifications—PRICE 75¢

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ENGINEERING & DESIGN

***Alumina powder,*** *here being poured into a can, can be used in place of conventional potting compounds to protect electrical parts against moisture and heat.*

trical apparatus. Conventional mineral-filled asphalts, melt at 275-300 F.

2. The powder maintains its dry, granular form in use. Thus, electrical components can be removed for inspection or repairs by breaking the seal on the can and pouring out the powder. Conventionally potted components are almost impossible to reclaim successfully, according to Kirkwood and Key.

3. Alumina is completely inert. Thus, there is no fire hazard (either during potting operations or in use) — in contrast to inflammable asphalts or plastics resins.

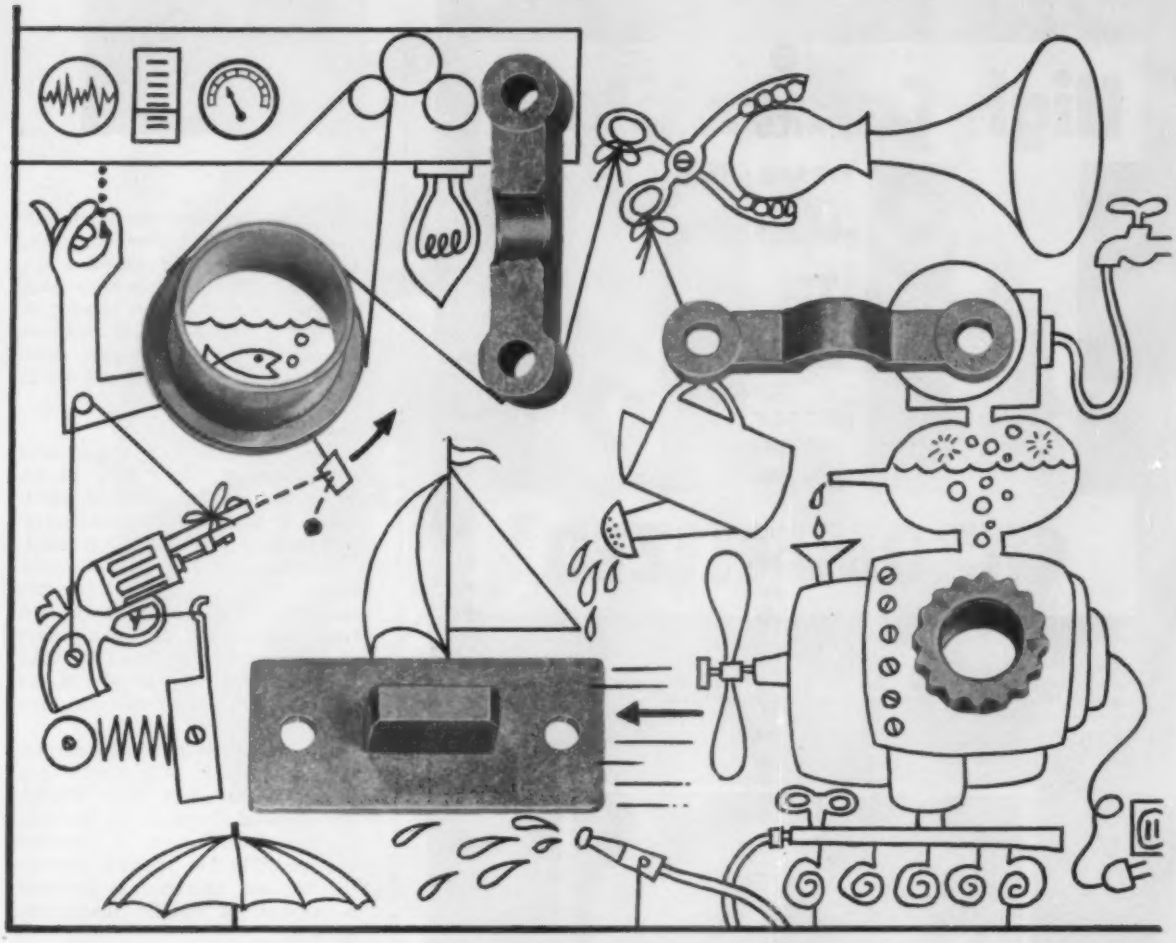
**Competes in price**

According to Kirkwood and Key, alumina powder is competitive in price with conventional potting compounds, and is equal to conventional potting compounds in electrical and heat transfer properties.

## Simple Device Sorts 'Look Alike' Metals

A device for sorting different metals that look alike has been developed by George Martin of General Electric Co.'s Knolls Atomic Power Laboratory, Schnectady 5, N. Y.

It consists of a standard milliammeter with two leads. One lead



*This thing wouldn't run when we plugged it in,*

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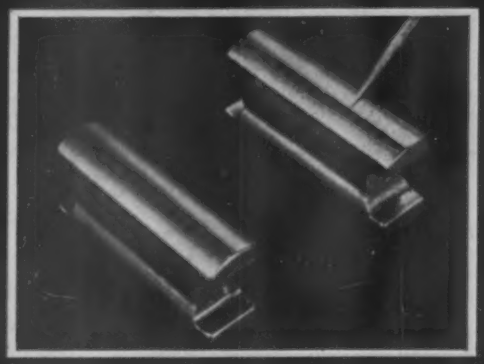
# High Carbon Steel

wears almost III times longer when

# CHROMALLIZED

HERE IS POSITIVE PROOF

In a test conducted by the Formsprag Company of Warren, Michigan, CHROMALLIZED sprags were removed from an automobile transmission after 55,000 miles of use and compared with ordinary sprags from another transmission after 33,000 miles of use. The CHROMALLIZED sprags showed less than half the wear of the other sprags.



Chromallized sprag (left) shows almost no wear, while an ordinary sprag shows considerable wear.

WHAT IS CHROMALLIZING?

A proven process of diffusing Chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes. CHROMALLIZING provides not only resistance to wear but also considerable resistance to corrosion and oxidation.

This process may be applied to superalloys and refractory metals for high temperature oxidation resistance.

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ends in a clamp and the other lead ends in a small carbon steel file. Metals are tested by attaching the clamp to, and rubbing the file briskly against, the metal whose identity is in doubt. The tester differentiates between Inconel and stainless steel, Zircaloy-2 and zirconium, and Zircaloy-2 and hafnium.

**How it works**

The rubbing of the file generates a tiny current, about 5 to 10 ma for Inconel and stainless steel, which causes a pointer to indicate on a dial the kind of metal being tested.

Martin says the device works because the polarity (electric charge) of stainless steel is different from the polarity of Inconel with respect to the carbon steel file. This also holds true for Zircaloy-2 and zirconium, and Zircaloy-2 and hafnium.

The tiny current which operates the milliammeter is a result of a thermoelectric effect, says Martin. The friction between the file and test specimen causes a localized hot spot. The hot junction between the file and specimen is sufficient to produce a readily measurable current.

**Thermocouple tester**

Another application for the device, which Martin feels may prove almost as important as its metal sorting ability, is as a thermocouple tester. In this application the device can be used to determine the polarity

***Inventor Martin** uses his new "metal sorter" to identify different metals commonly used in nuclear reactors.*

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ENGINEERING & DESIGN

of thermocouple leads during installation to insure that the leads are hooked up properly, and also to check out the circuit. If no polarity is indicated, the circuit is not complete.

## TFE Heat Shields Keep Parts Cool

TFE flurocarbon plastics show promise as expendable heat shields on rockets and missiles.

Recent research shows that a 0.1-in. thick aluminum sheet protected with a 0.32-in. thick TFE coating remains at room temperature for about 1 min after being exposed to a temperature of 2192 F. Within the next 80 sec the temperature of the metal rises to 1148 F, at which time the coating is completely removed.

### Decompose directly to gas

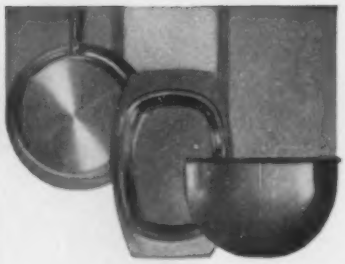
J. C. Siegle and P. H. Settlage of the Polychemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. say TFE plastics are particularly useful as heat shields because:

1. At extremely high temperatures, TFE resins turn directly into a gas, as opposed to other thermoplastics which melt to form a liquid. A tremendous amount of heat is absorbed by the TFE coating as it turns into a gas.

2. TFE resins do not melt to form a liquid, crack, spall or lose their mechanical properties up to temperatures above their melting point, i.e., 620 F. (Melting point for TFE resin, as determined by ASTM D1457-56T, is the temperature at which a shaving changes from milky white to gray translucent at the outer edges.) Since extremely high temperatures do not cause TFE resins to melt and form a liquid, a TFE heat shield would retain enough strength to withstand the crushing force of the earth's atmosphere upon rocket reentry.

### Permit lightweight construction

Big advantage of a TFE heat shield, say Siegle and Settlage, is that the material might permit use of lightweight metals such as aluminum in missile construction, replacing presently used heavy metals and ceramics.



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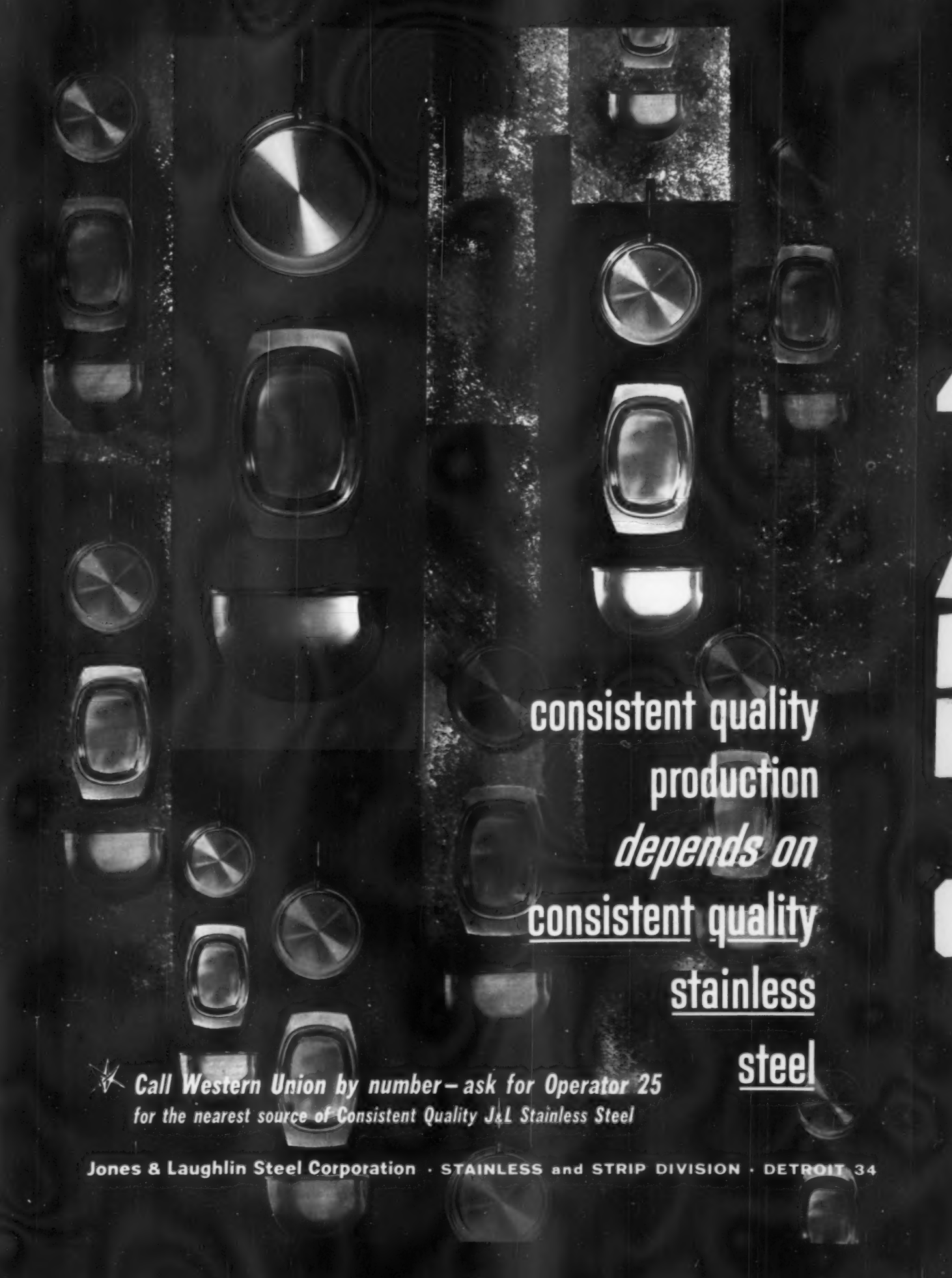
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TECHNICAL LITERATURE

*(cont'd from p 49)*

## *Books*

**Plastics Engineering Handbook of the Society of the Plastics Industry, Inc.: 3rd Edition.** *Reinhold Publishing Corp., New York. 1960. Cloth, 7 by 10 in., 597 pp. Price $15*

The present edition adds several new chapters to the second edition issued in 1954, and all of the other chapters have been considerably revised, or rewritten, to expand and bring up to date the material contained in the earlier editions.

There is much new material on nomenclature, cellular plastics, decorating, welding, and plastics as adhesives. The book describes every step in compression, transfer and injection molding, and gives information on extrusion and extrusion machines, cold molding, preforming, casting, plastics tooling, embedding and potting, and design of molds and dies.

The text is fully illustrated.

---

**Books on Nuclear Metallurgy.**

**Metallurgy and Fuels: Volume 2.** *Edited by H. M. Finniston and J. P. Howe. Progress in Nuclear Energy Series 5. Pergamon Press Inc., New York. 1959. Cloth, 6 by 9 in., 675 pp. Price $21*

Discusses the properties, fabrication and nuclear uses of beryllium, magnesium, ceramics, thorium, uranium, plutonium, zirconium, and fuels and fuel elements. The book also discusses radiation effects in structural materials at elevated temperatures, low temperature irradiation and annealing effects in graphite, effects of radiation on mechanical properties of solids, strength and creep of uranium alloys, and effect of neutron irradiation on crystalline and glassy inorganic solids.

**Nuclear Metallurgy: Volume 6.** *Metallurgical Society of AIME, New York. 1959. Price $7*

Discusses the behaviour of metallic and ceramic fuel materials, and explains phenomena such as growth, swelling, and radiation-induced phase transformations that limit the useful life of metallic fuels. The book aso discusses the irradiation behaviour of engineering materials.

---

**Ferrites.** *J. Smit and H. P. J. Wijn. John Wiley & Sons, Inc., New York. 1959. Cloth, 6 by 9 in., 384 pp. Price $10*

Gives physical properties of ferrimagnetic oxides. These properties are in turn treated in relation to the chemical composition and crystal structure of the materials.

**Basic Mechanisms of Fatigue.** *American Society for Testing Materials, Philadelphia. 1959. ASTM Special Technical Publication No. 237. Cloth, 6 by 9 in., 127 pp. Price $3.75*

Subjects include: 1) internal friction, plastic strain, and fatigue in metals and semiconductors; 2) cycle-dependent stress relaxation; 3) recent observations on fatigue failure in metals; 4) fatigue crack forma-

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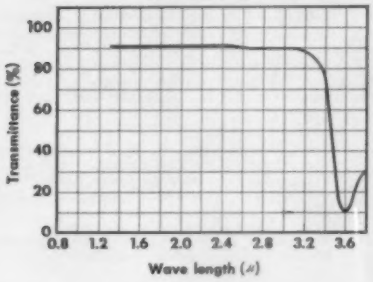


*Both actually increase in mechanical strength as the temperature goes up.* Odd, what?

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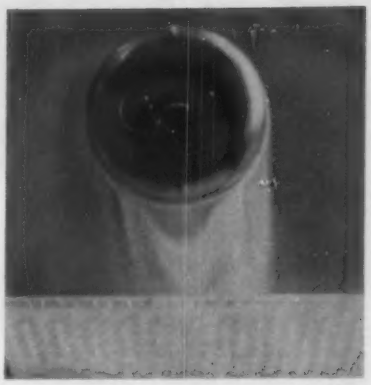

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## TECHNICAL LITERATURE

tion in silver chloride; and 5) slipband formation and fatigue cracks under alternating stress.

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**Books on Castings, Stampings.**

**Foundry Engineering.** *H. F. Taylor, M. C. Flemings and J. Wulff. John Wiley & Sons, Inc., New York. 1959. Cloth, 5⅛ by 9 in., 410 pp. Price $9.75*

Presents a scientific approach to engineering principles and methods of foundry operation. Particularly outstanding are the treatments on solidification and structure of cast metals, and on principles of correct gating and risering of castings.

**Machine Shop and Foundry Projects.** *H. J. Kauffman. McKnight & McKnight Publishing Co., Bloomington, Ill. 1959. Cloth, 6¾ by 10 in., 85 pp. Price $3.80*

**Practical Design of Sheet Metal Stampings.** *Federico Strasser. Chilton Co., Book Div., Philadelphia. 1959. Cloth, 6 by 9 in., 183 pp. Price $10*

Discusses major pressworking processes; principles of good stamping design; and bent, formed, drawn, embossed, hot and cold pressed, and curled components. The book also discusses special problems in metal stamping. It is illustrated with over 500 drawings.

---

**Tool Engineering.** *S. E. Rusinoff. American Technical Society, Chicago. 1959. Cloth, 8½ by 5½ in., 336 pp. Price $6.75*

Information on tool design, estimating, dimensions, tolerances and quality control.

**Collected Papers on Tool Engineering, Book 2, Volume 59.** *American Society of Tool Engineers, Detroit. 1959. Price $10*

Articles on product engineering, fabricating processes, tool design, metalworking principles, metal forming, engineering materials and quality control.

---

**ASTM Standards on Materials.** *American Society for Testing Materials, Philadelphia.*

**Standards on Metal Powders and Metal Powder Products.** *1959. Cloth, 6 by 9 in., 96 pp. Price $2.25*

Covers metal powders, bearings, structural parts, carbides, heavy metals, and terminology relating to powder metallurgy. Incudes a general description of production processes, mechanical properties, and uses of metal powder sintered bearings and structural parts.

**Standards on Electrical Insulating Materials.** *1960. Cloth, 6 by 9 in., 792 pp. Price $8.75*

Covers insulating shellac and varnish, plates, sheets, tubes, rods, molded materials, ceramic products, encapsulating compounds, insulating papers, mica products, magnet wire insulation, plastics insulation, rubber tapes, and textile materials for electrical insulation.

**Standards on Textile Materials.** *1959. Cloth, 6 by 9 in., 988 pp. Price $8.50*

Covers nonwoven fabrics; jute and kraft yarns; and asbestos, cotton, glass, wool and man-made fiber textiles.

---

**Books on Vacuum Technology.** *Pergamon Press Inc., New York. 1959.*

**Fifth National Symposium on Vacuum Technology Translations.** *Edited by W.G. Matheson. Cloth, 8½ by 11 in., 282 pp. Price $15*

Discusses fundamental basis of vacuum techniques, applied science and research, vacuum systems and components, vacuum in-

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President
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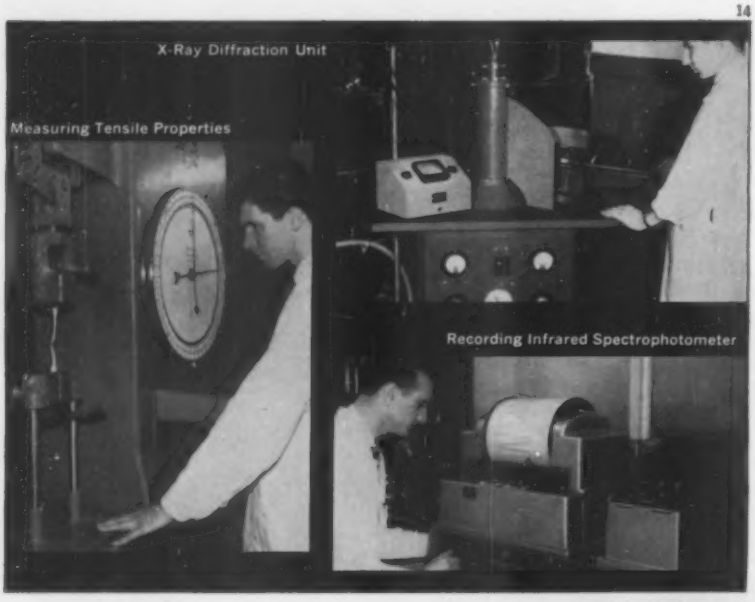


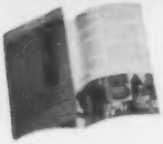

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TECHNICAL LITERATURE

strumentation and controls, education in vacuum technology, ultra high vacuum, vacuum-deposited magnetic and thin films, and industrial applications and processes.

**Progress in Vacuum Science and Technology.** *Edited by A. S. D. Barrett. Cloth, 8½ by 10½ in., 160 pp. Price $10*

Information on vacuum metallurgy, distillation, drying and fumigation. Also, the use of vacuum technology in the manufacture of valves.

## *Reports*

**Patents and Inventions** PATENTS AND INVENTIONS: AN INFORMATION AID FOR INVENTORS. *25 pp. 1959. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15¢*

This report is designed to help inventors in deciding whether to apply for patents, in obtaining patent protection, and in promoting their inventions.

**Titanium alloy** DEPARTMENT OF DEFENSE TITANIUM SHEET ROLLING PROGRAM: STATUS REPORT NO. 4. *H. R. Ogden, Defense Metals Information Center, Battelle Memorial Institute. Mar '59. 98 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.25 (PB 151065)*

Discusses a new titanium alloy, Ti-13 V-11 Cr-3 Al, capable of being heat treated to such high strength levels that new target properties had to be specified for it.

**Vacuum melted alloy** VACUUM-INDUCTION, VACUUM-ARC, AND AIR-INDUCTION MELTING OF A COMPLEX HEAT-RESISTANT ALLOY. *R. F. Decker, J. P. Rowe and J. W. Freeman, University of Michigan. Aug '59. 43 pp. Available from National Aeronautics and Space Administration, Washington, D. C. (No. D-6)*

Study of the relative hot workability and creep-rupture properties at 1600 F of a complex 55 Ni-20 Cr-15 Co-4 Mo-3 Ti-3% Al alloy for vacuum induction, vacuum arc and air induction melting.

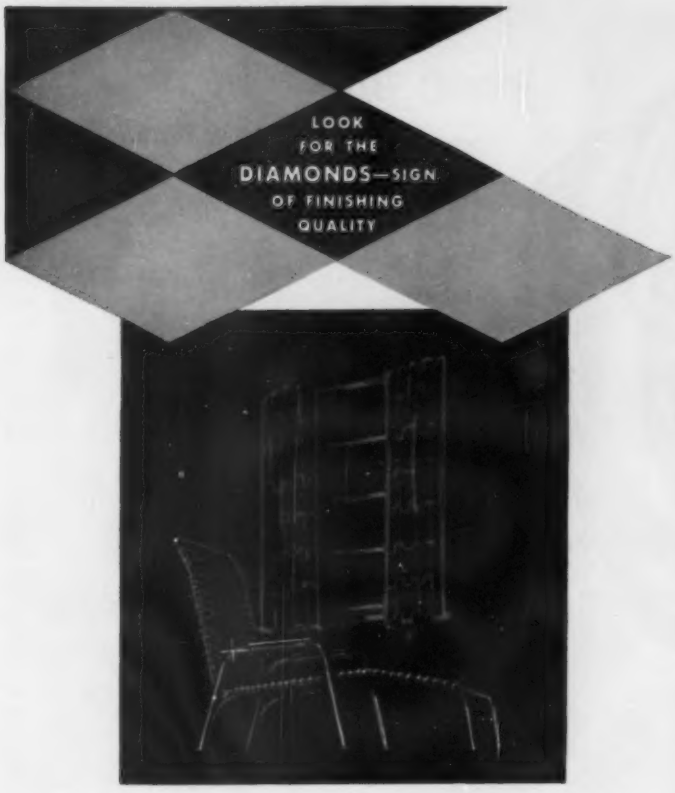
**Electrolytic production of titanium** ELECTROCHEMISTRY OF MOLTEN ALKALI AND ALKALINE EARTH HALIDES CONTAINING HALIDES OF TITANIUM. *C. T. Brown and others, Rensselaer Polytechnic Institute. Oct '57. 141 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $3 (PB 151155)*

Contains a short review of systems used for electrolytic production of titanium. Includes electrochemical properties of molten alkali and akaline earth halides containing halides of titanium

**Sandwich design** STRUCTURAL SANDWICH DESIGN CRITERIA. *Forest Products Laboratory, Madison 5, Wis. 1959. 16 pp.*

Presents design criteria for structural sandwich constructions under various types of loading.

**Fuel elements** REPORT OF FUEL ELEMENTS CONFERENCE HELD AT GATLINBURG, TENN. MAY 14-16, 1958. *United States Atomic Energy Commission. 1959. 300 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $3*

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News OF INDUSTRY

*Reinforced Plastics—cont'd from p 31*

hollow mandrel molded out of salt was simply "washed out" of the core after the hollow shape was wound.

**Tensile tests and impact strength**

Design criteria for mechanical joints was discussed by Strauss of Martin Co. A method of correlating results of tensile tests with impact strength was described by Bobalek and Evans of Case Institute. The authors pointed out that reinforced plastics can be produced with impact resistance equal to that of the most impact resistant thermoplastics, yet with markedly superior resistance to permanent deformation and failure.

**Three new materials**

Although radically new materials were somewhat conspicuous by their absence, the following three papers seem noteworthy: results of thermal aging studies made on fused silica yarn (Plant, Gerard and Wisely, General Electric); properties of laminates made with solventless silicone resins (Retford, Nelson and Hoffman, Dow Corning); and use of cross-creped kraft paper as reinforcement for plastics (Calvin, Cincinnati Industries).

## Special Courses Cover Engineering Materials

Here is the first installment in our annual spring coverage of special courses on engineering materials being offered by leading universities and colleges:

**New York University**—*Vacuum Metallurgy (June 2-3):* short course designed to acquaint practicing engineers with advanced engineering information on vacuum metallurgy and the latest research developments in the field.

**Pennsylvania State University**—*Machinability (June 6-10):* emphasizing the new difficult-to-machine materials, this seminar will cover fundamentals, new developments, methods and techniques, and practical appli-

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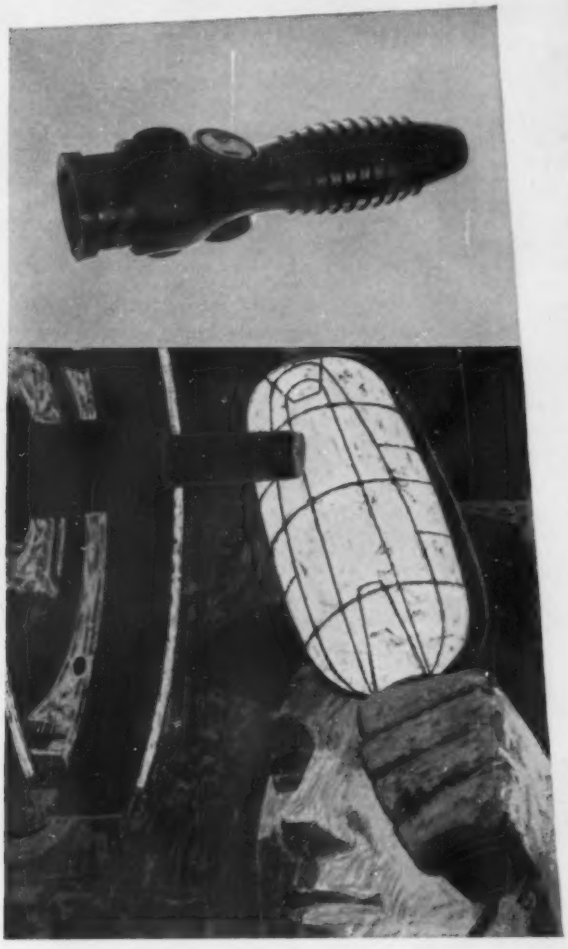

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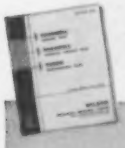
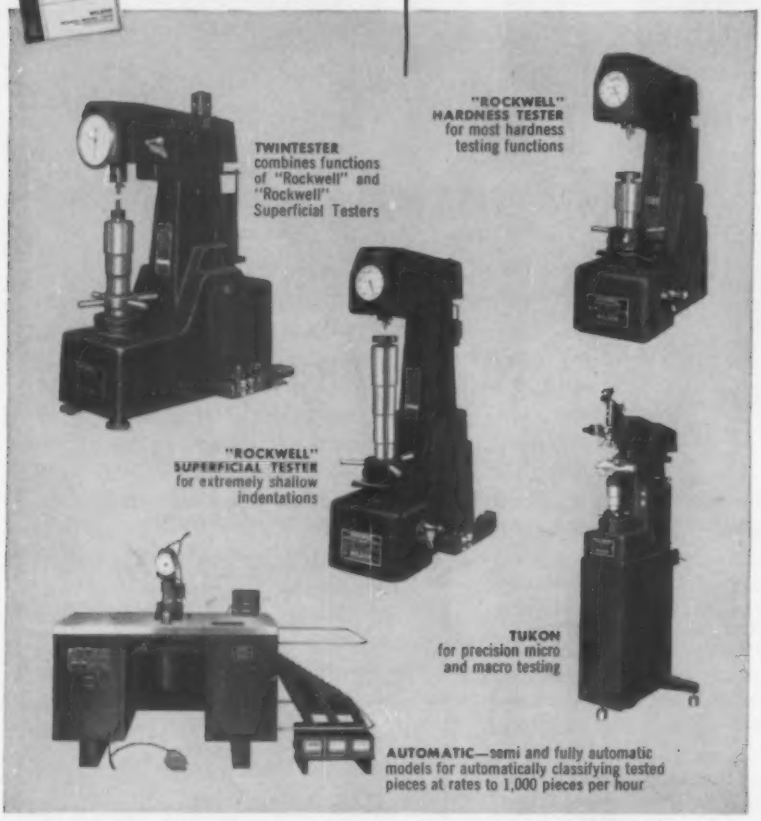


*Write* for Catalog RT-58. It gives complete details on the full line of Wilson hardness testing equipment.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## News OF INDUSTRY

cations of the results of metal cutting research. *Design Engineering (June 12-17):* seminar aimed at stimulating imaginative and creative thought in design engineering, and developing methods and procedures in syntheses applicable to design projects or systems.

**Boston College**—*Industrial Spectrography (July 18-29):* use of spectrography as an analytical tool.

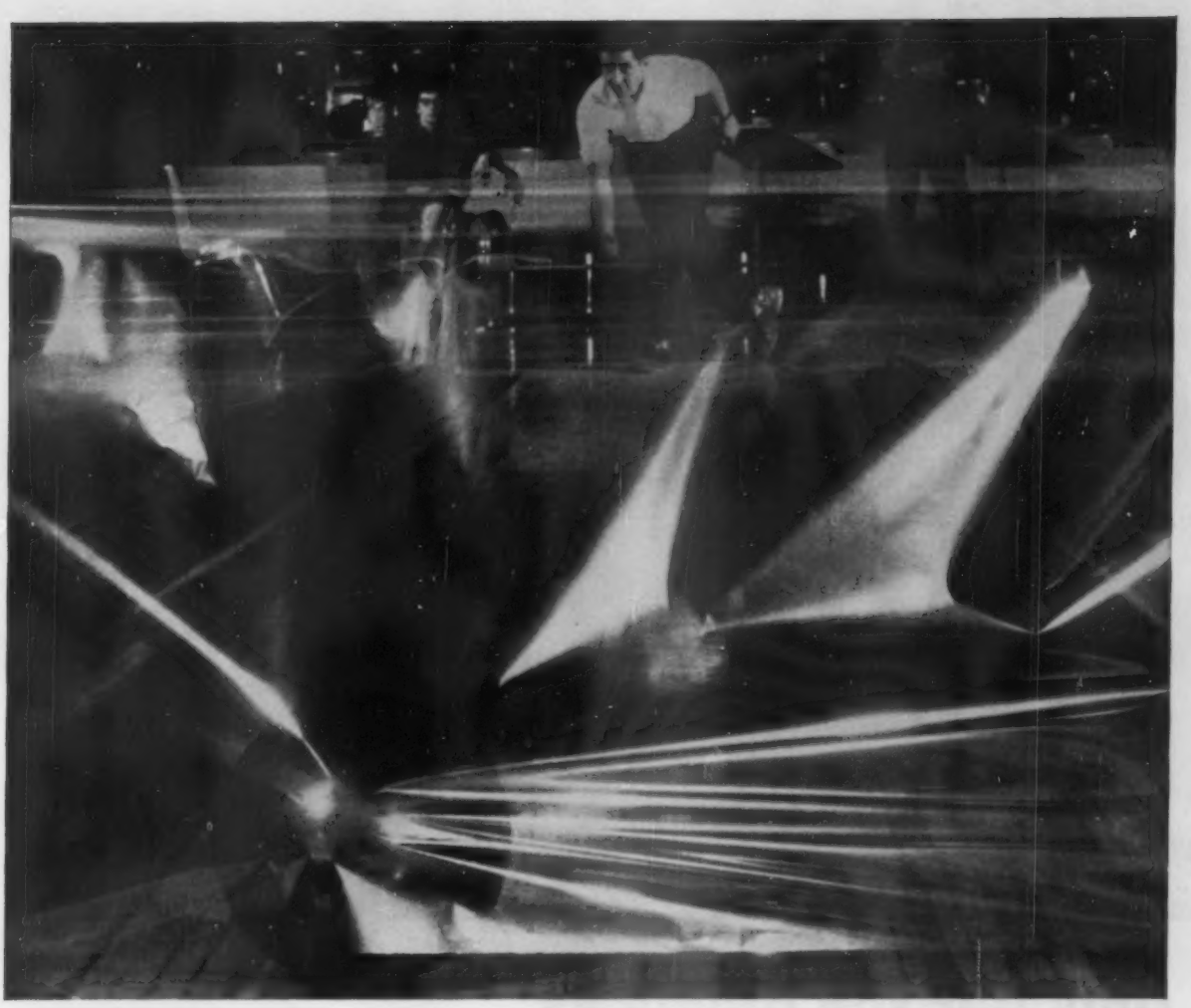
**University of Michigan** — *Applied Mathematics (July 11-20):* designed to provide engineers with mathematical tools for formulating and solving partial differential equations governing steady and unsteady state phenomena. *Semiconductors (July 11-23):* fundamentals and advanced concepts of solid state physics.

**Massachusetts Institute of Technology**—*Solidification of Metals (Aug 22-26):* practical examples of how the properties and reliability of castings and forgings can be enhanced by improved control over the solidification pattern of the casting (or ingot). Among the topics to be covered: mechanism of solidification, heat transfer in metal and refractory molds, segregation and microporosity in ferrous and nonferrous metals, vacuum melting, thermodynamics of metals, and techniques for producing premium quality aluminum, magnesium and steel castings.

## New Welding Processes Covered at Conference

New welding developments in missiles, supersonic aircraft and nuclear power installations were featured at the recent Midwest Welding Conference sponsored jointly by Armour Research Foundation and the Chicago Section of the American Welding Society.

The two-day conference opened with a paper (by Burns of Thiokol) describing solutions to the joining problems encountered during development of the Minute Man missile. It went on to cover practically all phases of welding, including the most recent developments in brazing and arc and resistance welding.



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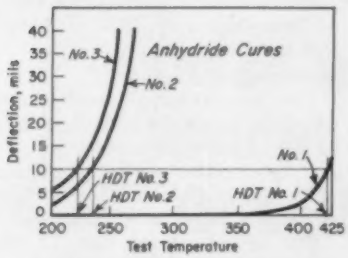
*New Epoxies—cont'd from p 20*

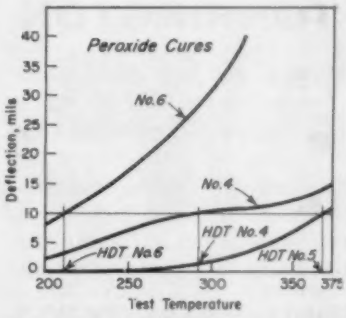
**TABLE 1—TYPICAL PROPERTIES OF OXIRON EPOXIES[a]**

| Oxiron Type → | Castings | | | Laminates[b] |
|---|---|---|---|---|
| | 2000 | 2001 | 2002 | |
| **MECHANICAL PROPERTIES** | | | | |
| Flexural Strength, 1000 psi | 10.1-16.2 | 15.4-18.1 | 16 | 57.6-64.5 |
| Flexural Modulus, $10^5$ psi | 3.4-4.8 | 4.2-4.9 | 4.9 | 2.6-2.8 |
| Tensile Strength, 1000 psi | 4-6.8 | 5.6-9.7 | 7.4 | (33.3-44)[c] |
| Tensile Modulus, $10^5$ psi | 1.0-7.5 | — | 8.2 | — |
| Rockwell Hardness, M | 83-98 | 94-114 | 83 | — |
| **ELECTRICAL PROPERTIES** | | | | |
| Volume Resistivity, ohm-cm | | | | |
| Room Temperature | $1.5\text{-}4.9 \times 10^{15}$ | $4\text{-}62 \times 10^{14}$ | $4.4 \times 10^{14}$ | $6.6 \times 10^{12}\text{-}1.4 \times 10^{15}$ |
| After 7 Days, 140 F, 95% RH | $6.5\text{-}43 \times 10^{13}$ | $0.6\text{-}1.3 \times 10^{13}$ | $2.9 \times 10^{14}$ | $5.3 \times 10^{12}\text{-}1.2 \times 10^{14}$ |
| Dielectric Constant | | | | |
| Room Temperature | | | | |
| 60 Cps | 3.17-3.37 | 3.06-3.34 | 3.18 | 4.07-4.26 |
| $10^6$ Cps | 2.97-3.19 | 2.88-3.24 | 2.97 | 3.88-4.06 |
| After 7 Days, 140 F, 95% RH | | | | |
| 60 Cps | 3.90-4.49 | 3.82-4.49 | 4.01 | 2.03-6.4 |
| $10^6$ Cps | 3.50-3.79 | 3.21-4.03 | 3.45 | 2.67-4.25 |
| Dissipation Factor | | | | |
| Room Temperature | | | | |
| 60 Cps | 0.006-0.009 | 0.004-0.016 | 0.005 | 0.006-0.012 |
| $10^6$ Cps | 0.016-0.022 | 0.015-0.023 | 0.018 | 0.012-0.029 |
| After 7 Days, 140 F, 95% RH | | | | |
| 60 Cps | 0.009-0.03 | 0.008-0.04 | 0.029 | 0.014-0.055 |
| $10^6$ Cps | 0.034-0.051 | 0.032-0.05 | 0.036 | 0.021-0.045 |

[a]Values cover range obtained with various curing agents; all specimens heat cured.
[b]12-ply, 181 Volan A cloth, press molded at 25 psi; all specimens postcured 3 hr at 310 F.
[c]Edgewise compressive strength.




**1 *High HDT*** *(heat distortion temperature) of about 420 F is obtainable with maleic anhydride, as shown by curve No. 1. Curves No. 2 and 3 were obtained with anhydride-propylene glycol curing agents.*

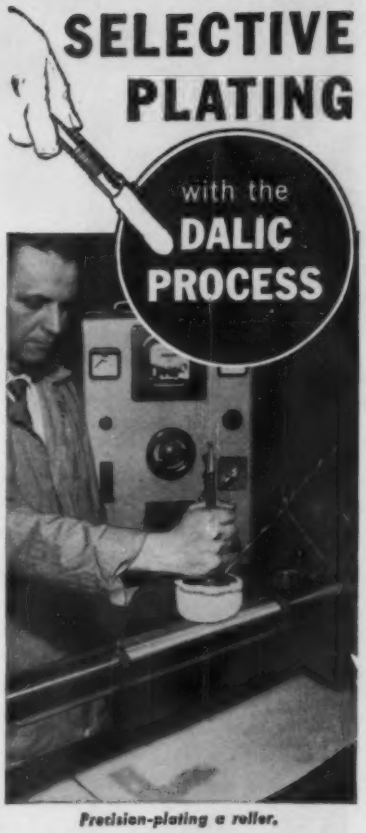



**2 *Flat deflection curves*** *are obtained with anhydride, propylene glycol and dicumyl peroxide cures.*

### Properties

The accompanying table shows mechanical and electrical property ranges obtained with both unfilled castings and laminates. A variety of curing agents were used. All specimens were postcured. Laminated specimens were press cured at 25 psi, followed by oven-postcuring. In general, the Oxiron resins display lower and more controllable exotherms than conventional epoxies during cure.

Oxiron resins can be formulated to provide excellent heat resistance. Fig 1-3 show typical values for deflection vs temperature under the ASTM standard 264 psi load. Fig 1 shows the high 420 F value for a maleic-anhydride-cured casting. Fig 2 shows the flat curve obtainable with peroxide curing agents, result-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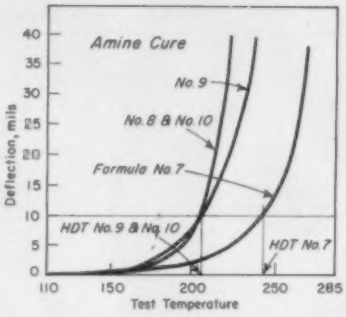



**3 Moderate HDT values,** *but good pot life, are obtained with aromatic (No. 7 and 8), and aliphatic (No. 9 and 10) polyamine cures.*

ing in only small deflection increments over a relatively wide temperature range. Such behavior is of considerable value in load-bearing applications.

According to the producer, comparative tests show that conventional amine-cured epoxy castings become completely embrittled after 250 hr at 300 F. Tensile strengths drop about 30%. Under the same conditions amine-cured Oxiron 2000 castings after 720 hr—three times as long—lose only 40% of initial strength.

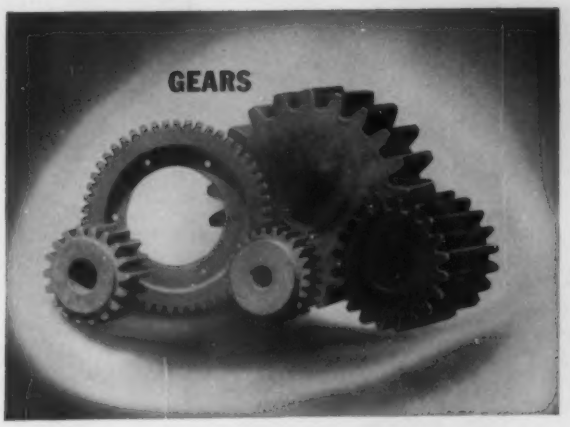
**Applications**

For encapsulating electrical or electronic components, the materials offer good high temperature stability and comparable electrical properties. Low temperature reactivity with anhydrides should be of advantage.

The slow reaction rate of the resins with amine curing agents at room temperature, and the rapid reaction at elevated temperatures would provide prepreg materials with good shelf life, yet rapid curing characteristics. For wet lay-up techniques the resins offer good pot life, and are said to wet glass well, providing good adhesion when cured at low pressures for short times.

Excellent adhesion to other mate-

**SOURCES** of most engineering materials can be found in the third edition of M/DE's *Materials Selector* reference issue, published last October. Properties of all materials are also given.



*Low-cost and with controlled electrical properties.* CDF Celoron Molded Plastics are designed for use in electrical and mechanical applications requiring high impact strength with good mechanical and electrical properties.

# Close tolerances and high finish with phenolic resin-impregnated CDF CELORON® MOLDED PLASTICS

CDF Celoron Molded Plastics give you all the advantages of low-cost form molding of electrical and mechanical parts. You can even add strength selectively to any section of the item.

*Through lower unit costs,* CDF Celoron Molded Plastics offer you longer life per dollar invested. Resist water, oil, grease, and many other corrosive solutions and atmospheres. In gears, they operate without continuous lubrication at temperatures of up to 150°F.—300°F. in oil. CDF Celoron Molded Plastics are also sound-absorbent, shock-resistant, and abrasion-resistant.

You can save machining time through CDF's custom molding and complete fabrication facilities. You'll also save costs through CDF's mass production of Celoron parts.

*See your CDF sales engineer today.* He'll show you how CDF Celoron Molded Plastics, plus complete custom molding and fabrication, can save you production time and costs.

**CONTINENTAL-DIAMOND FIBRE**

A SUBSIDIARY OF THE Budd COMPANY, NEWARK 25, DEL.

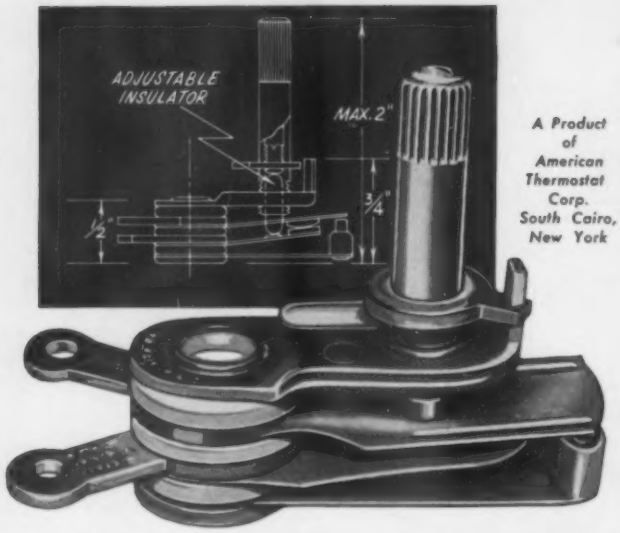
For more information, turn to Reader Service card, circle No. 409

# Chace THERMOSTATIC BIMETAL

*Actuates Another Precision Product*

THE ATC **american**

MODEL A-7
THERMOSTAT




*A Product of American Thermostat Corp. South Cairo, New York*

**This compact, adjustable thermostat is used by manufacturers of bakers, coffee makers, deep fryers, roasters, solder cups, sealing machines, water heaters and other appliances and industrial and laboratory devices. It is precision assembled for uniformity of calibration range and is so constructed that the bimetal element is not subjected to mechanical stress after disconnection if the thermostat is left "On" at high heat. The heavy-walled rivet eliminates calibration change due to mounting pressure and the silver contacts are welded to stainless steel springs. Other features: trimmer set screw, single screw mounting, rigid control bracket for permanent alignment. The useful range for which units can be supplied calibrated is from 70° to 600° F. Ratings: AC, to 230 v., 1650 w.**

**"Uniformity" has long been a watchword at Chace because it is uniformity of bimetal performance that saves millions of users of appliances and other temperature-actuated devices from the annoyances and dangers of unpredictable waffles, scorched deep-fat, overheated solder and the like. And the many "uniformities" in Chace Thermostatic Bimetal are the result of over a third of a century of research and development, of advanced processes, of constantly improved precision equipment and of relentless testing and inspection. Add to all this the well-known Chace integrity and you'll know why your name is safe on the outside with Chace bimetal inside.**

**Remember, Chace bimetal is available in coils, strips and completely fabricated elements of your design. Send now for "Successful Applications of Chace Thermostatic Bimetal" containing many pages of valuable design data.**

IT BENDS WITH THE HEAT

**W. M. CHACE CO.**
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

**For more information, turn to Reader Service card, circle No. 470**


What's new IN MATERIALS

rials promises applications in adhesive formulations, as well as coatings. The resins are reactive to phenol formaldehyde resins as well as to polyhydric phenols. They may be used alone or with phenolic or nitrogen resins, or through conversion to resin esters. **KEY NO. 606**

## Resistance Wire for Service at 400-600 F

Two new developments in electrical resistance wires have been announced recently. One is an electrical resistance wire insulated with a combined ceramic-TFE material for service up to 400-600 F. The other is a new nickel-chromium wire with a low temperature coefficient of resistivity.

### 1. Insulated wire

The ceramic-TFE insulated electrical resistance wire can be used continuously at temperatures up to 480 F, and intermittently at temperatures up to 570 F. The wire is available from Kanthal Corp., Amelia Pl., Stamford, Conn.

The two-layer electrical insulation is available on iron-base and nickel-chromium electrical resistance alloy wires. Diameter of the insulated wires ranges from 0.001 to 0.0045 in.

The ceramic-TFE insulation, called Ceron and developed by Sprague Electric Co., North Adams, Mass., is said to have excellent resistance to heat and solvents.

The combination of a ceramic undercoating with an overlay of TFE produces an electrical insulation with better mechanical and electrical properties than a ceramic or a TFE coating alone. The rubbery surface of the insulation has a slick, self-lubricating finish. **KEY NO. 607**

### 2. Nickel-chromium wire

The nickel-chromium wire is designed for use on resistors and potentiometers in electronic control devices.

A big feature of the material is that it has a temperature coefficient of resistivity of only 0 $\pm$0.00001 per ° F over the temperature range $-80$ to 300 F.

The wire is made from a new alloy that contains 74% nickel, 20% chromium and small percentages

# NOW—15,000°F. PLASMA FLAME SPRAY IN YOUR OWN PLANT

Flame spraying hi-temperature crucible

## Apply coatings of high melting point materials such as tungsten, tungsten carbide, molybdenum, chromium carbide, titanium oxides, calcium zirconate, rare earth oxides. Operates at 10,000°—15,000°F.

**Now any material that can be melted without decomposing can be sprayed. Despite high melting temperature, object sprayed stays cool.**

**High fluidity of particles and high velocity of impingement bond particles together to produce high density coatings semi-fused to work surfaces. Absence of air eliminates oxidation.**

Spraying tungsten on brass mandrel

Tungsten coated graphite part

### Metco Type MB Plasma Flame Spray Gun

Here is a valuable new tool for the metalworking research department or production line. The METCO Plasma Flame Spray Gun operates on inexpensive inert gases, with high electrical power conversion efficiency and long component life. Continuous hot gas streams, as high as 30,000°F., with accurate control of temperature, can be generated for costs of ⅓ to ½ those of oxygen-fuel gas equipment for equivalent heat output.

Other advantages include push-button operation, extremely simple training of personnel, elimination of flash-back and explosion problems.

### Materials that can be sprayed

Specifically, a wide range of metals and their oxides, carbides, borides, and refractories have been sprayed with the standard apparatus on various shaped objects and mandrels. Coating densities are easily controlled and up to 98% of theoretical can be obtained. Lowered oxide contents, with improved bond and tensile strengths are additional advantages.

### Plasma Flame — how it works

The METCO Plasma Flame Spray Gun produces an arc contained in a water-cooled nozzle. An inert gas, blown through and around the arc, is "excited" to energy states having temperatures approaching 30,000°F. This Plasma "Flame" is used for melting and spraying any desired material.

**The METCO Plasma Flame Gun is the latest development in flame-spraying equipment by METCO. Write today for free bulletins describing the various flame spraying processes and the Plasma Flame Spray Gun.**

## Metallizing Engineering Co., Inc.

METCO

Flame Spray Equipment and Supplies
Westbury, Long Island, N. Y. • Cable: METCO
Telephone: EDgewood 4-1300
In Great Britain: METALLIZING EQUIPMENT CO. LTD.
Chobham-Near-Woking, England

Metallizing Engineering Co., Inc.
1175 Prospect Ave., Westbury, L. I., New York

Please send me free bulletin on the Metco Plasma Flame Spray Gun.

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____

For more information, turn to Reader Service card, circle No. 370

# YOU GET ACCURACY + VERSATILITY WITH AN OLSEN XY ELECTROMATIC U.T.M.

Only the Tinius Olsen XY Electromatic U.T.M. puts the full versatility of an XY recorder at your fingertips. Using precision Olsen extensometers, specimen strain, even of fragile film, is measured and recorded in inches per inch—not assumed strain on a time basis. Uniform, consistently accurate and reproducible test results are assured—any time, anywhere with any Olsen testing machine.

**With a Tinius Olsen XY Electromatic you can:**

- Dial the exact speed you want—no gears to change. Selected speed is maintained automatically throughout the test.
- Select any range from full capacity to as little as 1/4000 capacity (3 lbs. on a 12,000 lb. machine) with the flip of a switch—even during test. All ranges calibrated in accordance with ASTM Standards. Frequent recalibration is not required to insure accuracy.
- Choose from a wide variety of recorder functions to suit your testing requirements.

The Tinius Olsen XY Electromatic gives you all the versatility you need in a universal testing machine. Get the full story.

***Write today for Bulletins 54 and 59.***

TINIUS OLSEN
TESTING MACHINE COMPANY
2010 EASTON ROAD • WILLOW GROVE, PA.
*Testing and Balancing Machines*

Trademark Reg. U.S. Pat. Off.

For more information, turn to Reader Service card, circle No. 402


## What's new IN MATERIALS

**PROPERTIES OF CHROMEL-R**

| | |
|---|---|
| Specific Gravity | 8.10 |
| Density, lb/cu in. | 0.295 |
| Coef of Ther Exp (68-212 F), per °F | $7.5 \times 10^{-6}$ |
| Tensile Strength, psi | 95-200,000 |
| Elongation (in 10 in.), % | 3-25 |
| Elec Res (68 F), ohms/cmf | 800 |
| Temp Coef of Resistivity (-80 to 300 F), per °F | $0 \pm 0.00001$ |

of other alloying elements (not revealed). The alloy, called Chromel-R, was developed by Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8.

The resistance wire is supplied in sizes ranging from 0.0004 to 0.0031 in. It is available bare or insulated with various types of coatings to meet specific application requirements. **KEY NO. 608**

## Thermoplastic Fibers for Use in Paper

Vinyl and styrene polymers in the form of highly oriented fibers offer an attractive means for economically incorporating thermoplastic resins in paper and nonwoven textiles. Reasons: their structure is similar to that of cellulosic fiber, they are easily incorporated in paper and textiles on existing equipment, and their price is low.

The fibers are available in developmental quantities from Union Carbide Plastics Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17. The vinyl fiber is designated VXKA-6112 and the styrene fiber SXKA-0121.

Both fibers are irregular in structure, with many fine fibrils extending out from the main fiber bundle (see accompanying photo). Diameter varies from 2 to 200 $\mu$, and length from very short to a maximum of 3/16 in.

**Paper products**

*Impregnated paper*—The properties of vinyl and styrene impregnated papers were compared with the properties of a control paper that contained no additives. The data showed the following:

1. Dimensional stability of paper increases with increases in fibrous resin content, with styrene being

**You who are responsible for the purchase of tubular goods are assured highest quality and product reliability when you specify Standard. Over the past forty years Standard has supplied countless miles of electric weld boiler and heat exchanger, pressure and mechanical tubing and oil country tubing and casing to chemical plants, refineries and industries around the world. Let Standard specialists analyze your problem—quote on your job.**

# STANDARD

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*Welded stainless tubing and pipe • Welded carbon steel mechanical • Boiler and Heat Exchanger • Exclusive rigidized patterns • Special Shapes • Oil Well Tubing and Casing • Light Weight Pipe • Steel Tubing—Sizes: ⅛" OD to 6" OD—.028 to .270 wall • Stainless Pipe and Tubing—Sizes ⅛" OD to 4¾" OD—.020 to .187 wall.*

For more information, turn to Reader Service card, circle No. 358

From these rings in aircraft hydraulic systems to high-temperature electrical insulation, "Teflon" from R/M answers the needs of modern design men . . . and R/M facilities meet modern production schedules.

# "TEFLON" comes of age at R/M

No longer is "Teflon"* the baby of the design field. In the hands of skilled processors like R/M, "Teflon" has solidly proved its unique properties in this field.

R/M has always offered "Teflon" in the widest range of forms and sizes—rods, sheets, tubes, tape, a variety of machined parts; and was among the first to offer etched "Teflon" for bonding. From R/M you get *complete "Teflon" service.*

When you bring your "Teflon" problem to R/M, it's in good hands, because R/M has helped solve other problems for an impressive list of exacting designers.

Call the nearest R/M district office listed below or write Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

*Du Pont TM for its TFE-fluorocarbon resin

R/M

PLASTIC PRODUCTS DIVISION
RAYBESTOS-MANHATTAN, INC.
Manheim, Pa.

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SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL

For more information, turn to Reader Service card, circle No. 463

## What's new IN MATERIALS

more effective than vinyl.

2. Abrasion resistance increases with increasing vinyl resin content. At a vinyl resin content of 45%, abrasion resistance was three to five times that of the control paper. The styrene fiber did not improve abrasion resistance significantly.

3. Wet tensile strength increases as fibrous resin content is increased.

4. Surface smoothness of paper is improved.

5. Grease resistance is imparted to paper by fibrous resins when adequate amounts are used.

Several physical properties of paper are degraded by fibrous resins, according to Carbide. Bursting and dry tensile strengths, and folding endurance all decrease as fibrous resin content is increased. Tear resistance also decreases with increasing fibrous resin content.

*Paper laminates*—Paper containing fibrous resins can be laminated under heat and pressure. The most outstanding quality of fibrous resin-paper laminates is their toughness, which surpasses that of conventional phenolic resin-paper laminates. Water absorption of the fibrous resin laminates is high compared with phenolic laminates. Sizing agents, such as rosin, may improve this property.

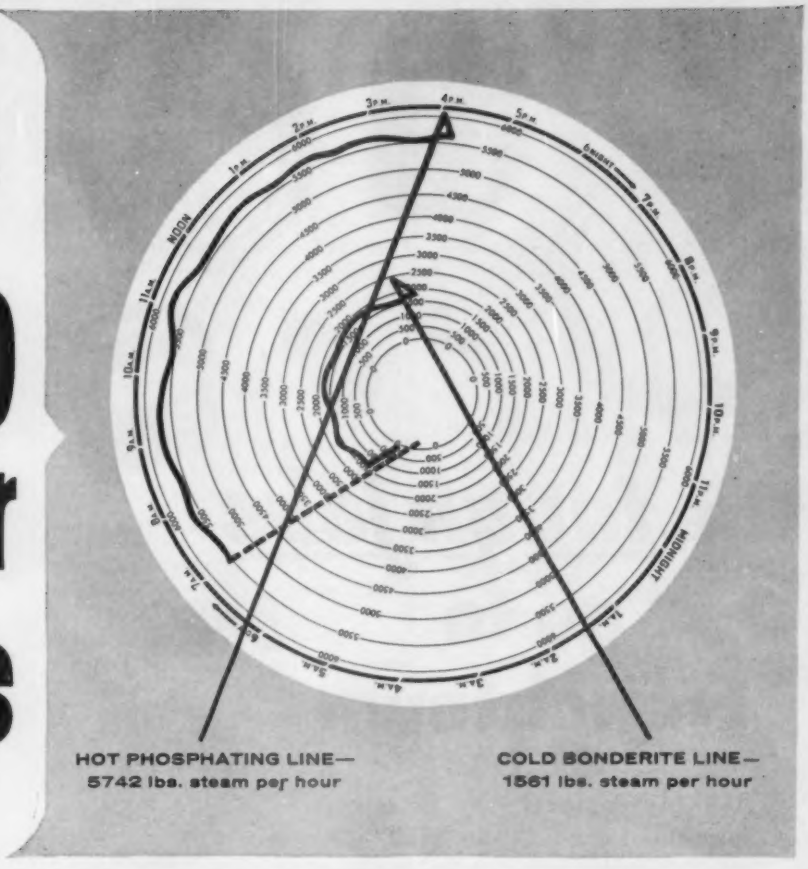
*Paper moldings*—Fibrous resin creped papers can be compression molded to form structures curved in three dimensions. Creped paper is necessary in order to obtain deep draws, according to Carbide. Low pressure molded items have a paper-like surface, whereas high pressure molded items have a hard glossy surface.

*Pulp moldings*—Only styrene fi-

**Fibrous resin** *at 370X.*

# STEAM RECORDERS SHOW

# $25,000 a year savings




## . . . WITH COLD BONDERITE SYSTEM

A manufacturer of household appliances decided to find out for himself! Steam recorders were hooked to two identical 5-stage phosphating lines—one using conventional hot solutions and the other line using the Cold Bonderite System.

Steam consumption on the "hot" line measured 5742 pounds per hour; the Cold Bonderite line used only 1561 pounds per hour. A difference of 4181 pounds, or *72.8%!*

Converted to dollars, the manufacturer estimates that Cold Bonderite, on all his production, will save $25,878 per year.

He is changing his other phosphating lines to the Cold Bonderite System as quickly as he can!

Cold Bonderite Systems operate at temperatures from 40 to 75° below conventional phosphate systems for surface treatment of metals. Coatings are of highest quality. Savings are *automatic.* Balanced formulation permits the use of accelerated solutions, easy to operate and control. You can choose between zinc or iron phosphates. Spray or immersion application to fit your production requirements.

The changeover to a Cold Bonderite System is simple and quick. Act now. You can have it installed and working to save you money by this time next week.

***Call in your Parker representative today!***

Since 1914— leader in the field

# Parker Rust Proof Company

2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

| | | | | |
|---|---|---|---|---|
| BONDERITE corrosion resistant paint base | BONDERITE and BONDERLUBE aids in cold forming of metals | PARCO COMPOUND rust resistant | PARCO LUBRITE—wear resistant for friction surfaces | TROPICAL—heavy duty maintenance paints since 1883 |

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

For more information, turn to Reader Service card, circle No. 395

# the *tough jobs* go to Frenchtown

Ask any engineer why he selects Frenchtown *first* for those "must" jobs, and chances are he'll sum up his answer in a single word—*confidence!*

It's the reason, too, why more and more engineers make Frenchtown their number one supply source for high temperature ceramics, components, assemblies, ceramics-to-metal seals, metallized ceramics, and specialized body compositions.

Next time you are faced with one of those "tough jobs" and want to be sure to come up with the right answer—*fast*, check with Frenchtown. You'll be in good company.

Literature is available on Frenchtown materials and products. We'll be happy to send you copies without obligation. Write *today*.

**frenchtown** PORCELAIN COMPANY

FRENCHTOWN, NEW JERSEY

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bers are recommended for pulp moldings because of the temperature (350 F) involved in the molding process. Pulp is first dried under a pressure of 100 psi, then further pressed under a pressure of 1250 psi.

**Nonwoven textiles**

Dense, paper-like, nonwoven textiles with fibrous resin binders can be produced by heating in a press, by exposure to a stream of heated air, or by hot calendering.

KEY NO. 609

## Fluorescent Paints Applied with Adhesives

Pre-dried sheets of fluorescent paint with a pressure sensitive adhesive backing are now available from Morgan Adhesives Co., Stow, Ohio. The developer says the paint has an outdoor life expectancy of two years.

The paint is applied in three steps:

1. A sheet of paint is cut to fit the surface area on which it is to be applied.
2. A protective paper backing is stripped off the adhesive side of the paint, and the sheet of paint is positioned and put down firmly.
3. A layer of paper protecting the surface of the paint is removed, exposing a dry painted surface.

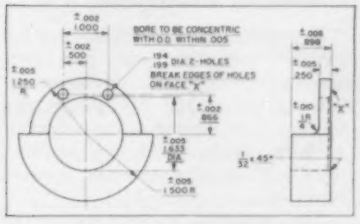
The developer says the pre-dried paint is expected to be used for

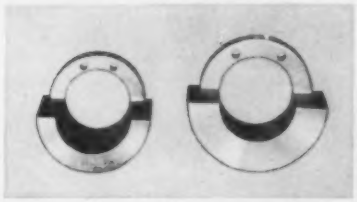
***Sheet of pre-dried paint** is applied by pressing it on part to be coated.*

# News from CRANE on Powder Metallurgy

## GRAY IRON CASTINGS VS. GRAY MATTER

Shown below are two of the 11 sizes of counterweights for crankshafts of refrigeration compressors. As the engineering drawing reveals, the tolerances are not too tight; offhand, it would appear to be an application for gray iron casting. And that's the way it used to be made.



Today, this same part is being made from Grade B-261D powder. (This is our own pre-mix of reduced iron powder plus graphite and zinc stearate.) The change-over to powder metallurgy was made in order to reduce manufacturing costs.

Unlike the casting, the powder part requires no machining. The powder is simply compressed to a uniform density of about 6 gm/cc in a press, sent through the sintering furnace, and the job is done. There are no costly hand finishing operations, and practically no rejects.

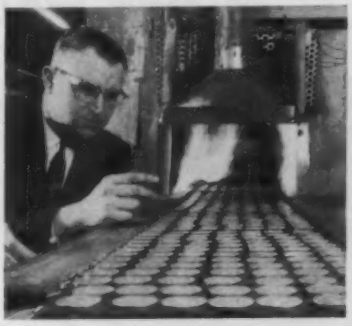
Interested in looking into the possibilities of converting some of your problems into solutions? More details are yours if you ask about *Item 1001.*

## IRON ANNIVERSARY

We are celebrating our 25th year of operation right now. In place of the conventional Silver Anniversary, our theme is Iron—what else? Since we first began to manufacture metal powders as an outgrowth of some interesting investigations from a Fellowship at Mellon Institute, iron powders have been part of our business.

As a memento of the occasion, we asked one of our customers, Compacted Metals Corporation of Waukegan, Ill., to produce these medallions for us. The material of which they are made is our own Grade B-210 Iron Powder, blended with small amounts of graphite and zinc stearate. Although they bear a resemblance to coins, there was no actual coining operation involved in their production. They are simply iron powder, compacted in a 75-ton press, and sintered at 2060° F for 35 minutes.

Care to share our anniversary with us? You are welcome to one of our memento medallions; we'll see that you get one—and more information, too—if you request *Item 1003.*



Mr. Rudolph Capon, President of Compacted Metals Corporation, inspects a PM medallion just before it enters the sintering furnace.

## AT THE DRAKE, SIR!

We hope you can be with us in Chicago on April 25, 26 and 27, where we will be exhibiting in the Powder Metallurgy Show at the Drake Hotel. Our station will be in Spaces 10 and 11, and we will enjoy renewing old acquaintances and greeting newcomers alike. Among the developments that have been going on in our company and our products this past year, there should be some items of mutual interest.

## FOR MORE INFORMATION

Each item on this page represents only the highlights from a field or laboratory report. In most cases there is considerably more information available. If you are interested in some phase or would even like to see the complete report, drop us a note mentioning the item number.

## PHYSICAL "FIT"NESS

When specs call for tough physical requirements, chances are they can be met by the judicious use of the right basic powders or mix. For instance, here are brief properties of two of our grades of iron powder and a competitive powder, compared to show changes in physicals resulting from adding 7% copper or 1% graphite, pressed at 30 tsi and sintered 30 min. at 2050°.

Many of our customers prefer to use our pre-blended grades of powder and have us blend to their specifications. This includes addition of appropriate compacting lubricants. They say they get a more uniform and reliable mix. If you would like more data on the physical changes wrought by varying combinations and amounts of additives refer to *Item 1002.*

| | Iron Powder Only | | | Iron Powder...7% Copper | | | Iron Powder...1% Graphite | | |
|---|---|---|---|---|---|---|---|---|---|
| | B-280 | B-281 | Comp. | B-280 | B-281 | Comp. | B-280 | B-281 | Comp. |
| Tensile*, psi | 27,500 | 36,000 | 21,000 | 40,500 | 47,000 | 39,500 | 25,000 | 42,000 | 22,000 |
| Elongation | 6% | 1% | 8% | 1% | .7% | .5% | 2% | 1% | 3% |
| Mod. of Rupt., psi | 68,500 | 72,000 | 52,100 | 77,500 | 98,500 | 74,500 | 59,200 | 94,000 | 48,000 |
| Radial Growth | +.20% | −.40% | +.12% | +1.85% | +.90% | +1.80% | +.2% | +.25% | +.15% |
| Hardness | 85 (RH Scale) | 100 | 75 | 50 (RB Scale) | 58 | 42 | 40 (RB Scale) | 55 | 10 |

*Based on standard MPI test bar laboratory data for comparison only. Physical data for specific parts will vary because of structure, design and other factors.

CRANE

**METALS DIVISION**

*formerly Plastic Metals Div. of National-U.S. Radiator Corp.*

4460 BRIDGE STREET
JOHNSTOWN, PA.

MEMBER: METAL POWDER INDUSTRIES FEDERATION

For more information, turn to Reader Service card, circle No. 376

# rolls your ring troubles away—

Closeup of ring rolling, showing edging roll and portion of ring.

# Edgewater ROLLED STEEL Rings

**Your choice of diameter and cross-section** —Complete, modern rolling, heat-treating and machining facilities enable us to produce steel rings *with precise accuracy* . . . in a large range of sizes and wide variety of cross-section shapes. Sizes are from 5 in. to 145 in. in diameter; shapes may be simple or complex. Edgewater rolling process minimizes finishing operations . . . provides rings of maximum strength, toughness and uniformity.

**Meeting your specifications** — Send us your drawings. We can furnish rings to closest tolerances or recommend revisions that will give you the best combination of performance and economy.

**Edgewater Steel Company**

P. O. Box 478, Dept. MDE Pittsburgh 30, Pa.

For more information, turn to Reader Service card, circle No. 390


## What's new IN MATERIALS

marking roads, pipelines, helmets, boats and sports equipment. It is also expected to be used for safety signs, outdoor posters, truck signs, advertising emblems, drum decals and store front signs. KEY NO. 610

### Flexible Fiberboard

A resilient, flexible fiberboard for special cushioning and packaging applications has been developed by Celotex Corp., 120 S. LaSalle St., Chicago 3. According to the producer, a ⅜-in. thick board can be bent over a 12-in. dia cylinder without breaking.

The material is expected to be used for packaging irregular shapes and fragile, delicate items. It is also expected to be used in the manufacture of certain automobile trim.

The new fiberboard is available in thicknesses ranging from ⅜ to 4 in. KEY NO. 611

### Urethane Foams Are Strong, Lightweight

New urethane foams now on the market include rigid and flexible materials based on either one or two-part polyether or polyester resin systems. The foams, combining high strength with light weight, are designed for use as insulating, cushioning and packaging materials.

**Rigid foams**

Nopco Chemical Co., Plastics Div., North Arlington, N. J. is marketing a rigid urethane foam that is available in both Freon and non-Freon formulas. The foam is said to have very low thermal conductivity, light weight and good flowability. KEY NO. 612

Another company, Isocyanate Products, Inc., 900 Wilmington Rd., New Castle, Del. is marketing a two-part, polyether-base rig'd foam that is said to have good load bearing and thermal insulating properties. The material is called Isofoam PE-2. KEY NO. 613

A third company, Mol Rez Div. of American Petrochemical Corp., 3134 California St. N.E., Minneapolis 18, Minn., is marketing a new polyester resin for rigid urethane foams. The

# News about COATINGS FOR METALS

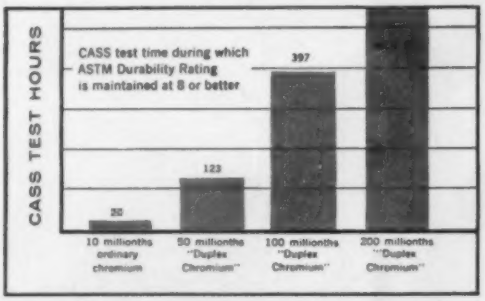
*from Metal & Thermit Corporation*

# The thicker the "Duplex Chromium" ... the longer the plating lasts

**The thicker this new, combination decorative chromium plate, the longer the finish lasts. This, in brief, is what accelerated corrosion tests show repeatedly. Increased corrosion resistance always results from thicker deposits of M&T "DUPLEX CHROMIUM"—whether tests are conducted by the CASS (1) or Corrodkote (2) methods.**

**This pattern of protection is consistent whether panels are steel, or zinc die castings. Note in the graph how the durability of the chromium plate is upgraded by thicker deposits. A thickness of 50 millionths of an inch of M&T "DUPLEX CHROMIUM" delivers a dramatic increase in durability. And a 100 millionths thickness enables samples to survive 100 CASS test hours and still maintain an ASTM durability rating at near the perfect level of 10. This achievement becomes all the more amazing when it is realized that automotive specifications till now only called for decorative chromium plate able to endure 16 hours of CASS.**

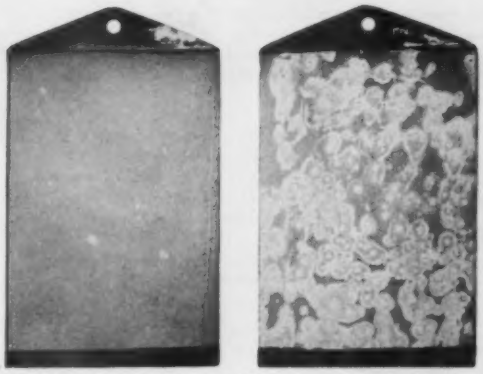
**Specifying the additional chromium thickness is a way to add years to the outdoor life of the bright finish. And for the ultimate in performance, M&T "DUPLEX CHROMIUM" now brings within reach of designers a decorative chromium plate that can last as long as they desire.**


CASS TEST HOURS
CASS test time during which ASTM Durability Rating is maintained at 8 or better
20
123
397
10 millionths ordinary chromium
50 millionths "Duplex Chromium"
100 millionths "Duplex Chromium"
200 millionths "Duplex Chromium"

**Graph indicates how corrosion resistance of chromium plate and ability to maintain ASTM durability rating of 8 or better in CASS testing increases with thickness. All test panels had 0.75 mil copper and 0.75 mil nickel undercoats—only the chromium was varied.**

### A UNIQUE DOUBLE PLATE

**M&T "DUPLEX CHROMIUM" consists of a deposit from the Unichrome Crack-Free Chromium bath, topped by a deposit from another special Unichrome SRHS® Chromium bath. The former blocks penetration of corrosives to the undercoats; the latter minimizes the effects of localized corrosion cells resulting from irregularities in the surface of the basis metal.**



**Left:** zinc die cast panels with 0.10 mil "Duplex Chromium" over copper and nickel undercoat, when subjected to 6 cycles of Corrodkote test, still rated 9.

**Right:** zinc die cast panel with 0.01 mil ordinary chromium over identical undercoats as panel to left rated only 1 after same 6 cycles.

**Both of these Unichrome SRHS® (self regulating high speed) baths are ideal for plating thicker chromium. They not only speed production but also simplify it. They give more uniform plate distribution and covering power, so that recesses, too, receive adequately thick deposits.**

**More data on tests and technology available. Send for your copy.**

(1.) Copper-accelerated acetic acid salt spray.

(2.) Standard, uniform highly corrosive slurry applied on test piece, which is then placed in non-condensing humidity cabinet. Each cycle is 16 hours.

**coatings and finishes**

METAL & THERMIT CORPORATION
General Offices: Rahway, New Jersey

For more information, turn to Reader Service card, circle No. 494

# FELT
BY FELTERS

PROVIDES DEPENDABLE,
LOW-COST PARTS FOR

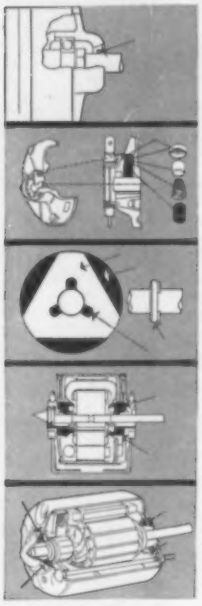
# ELECTRIC MOTORS

Seals . . . wicks . . . lubricators . . . washers . . . gaskets — are all vital electric motor parts that benefit from Felt by Felters.

A special Felters' "Engineered Fabrication" processes felt to specific thickness, density, hardness, and resiliency; and provides special characteristics such as absorption, stiffness, water repellency and flameproofing.

And, new felt and plastic laminates, called PlastiFelts, use synthetics such as Nylon, Teflon, Hycar and rubber to provide an even wider range of application, plus greatly improved performance.

These are some of the many electric motor applications where Felt by Felters offers both a low-cost and high performance material for non-metallic parts.



**Felt seal** inserted around shaft opening retains grease and keeps out foreign matter.

**This self-oiler** uses a felt wick, bearing against the shaft under spring pressure, for constant lubrication.

**This is a thrust washer** designed for double duty as a lubricator by the use of a felt ring and lubricating notches.

**Lifetime bearing lubrication** is possible by selection of correct SAE grade, and designing into sealed bearing.

**Felters' "Engineered Fabrication"** makes it possible to specify felt shapes for a complete motor and shaft lubricating system, combining reservoirs, and wicking, and directing oil flow to all required areas.

**To get the most out of Felt,** send for the Felters Design Book — a complete digest on properties and applications. Write, today.

*Ask for* **FELT** *from . . .*

The **FELTERS** Co.

220 SOUTH STREET
BOSTON 11, MASSACHUSETTS

*Pioneer Producers of Felt and Synthetic Non-Woven Fabrics* n5-6

## What's new IN MATERIALS

producer says the resin, called Pleogen 4002, should be formulated with a polyisocyanate and a blowing agent. Rigid foams made from the resin are said to have high strength, low thermal conductivity and good adhesion to wood, metals and reinforced plastics. **KEY NO. 614**

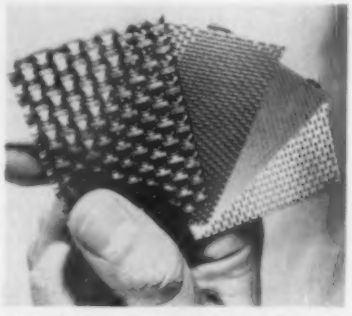
**Flexible foams**

A "one-shot" method for producing polyether-base, flexible urethane foams has been developed by General Tire & Rubber Co., 1700 Factory Ave., Marion, Ind. The flexible foam is said to have good load bearing and moisture resistance properties. It is lightweight, has high tensile strength, and good insulating properties. It can be stitched, sewn and stapled, and can be dry-cleaned. **KEY NO. 615**

Odorless, polyether-base, flexible urethane foams called High-Cushion Nopcofoam are now available from Nopco Chemical Co., Plastics Div., North Arlington, N. J. The producer says the foams can be made in an exactly controlled range of compressibility from very soft to very firm. The foam is supplied in medium or seating grade softness in 48-in. widths. **KEY NO. 616**

## Perforated Metal Has Long Service Life

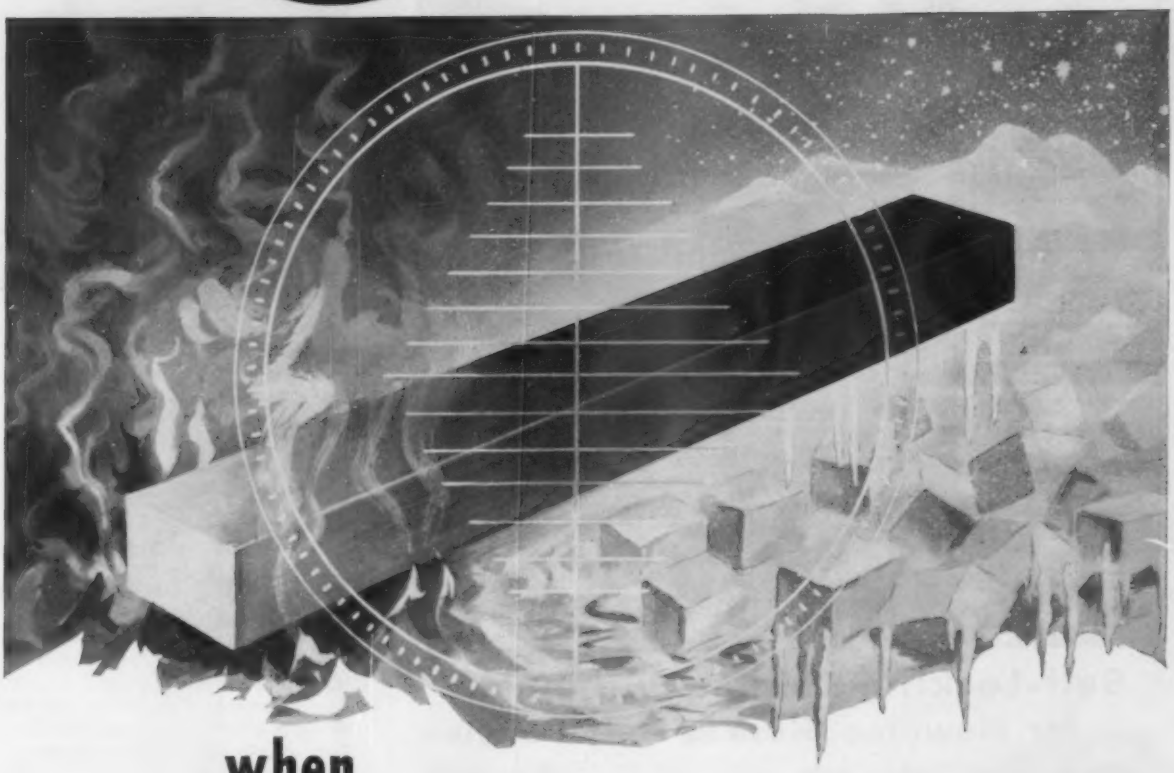
Perforated ferrous and nonferrous metals with trapezoidal, tapered openings are now available in the form of sheets, cones and cylinders from Cross Perforated Metals Co., Div. of National-Standard Co., Car-



***Diameter of openings** in new perforated metal ranges from 0.004 to 0.099 in.*

For more information, turn to Reader Service card, circle No. 399

# V-R METALS...



## when dimensional stability is needed!

Does the size of a metal part have to change as its temperature does . . . and if so how much?

The change in size under various conditions can be a very critical factor. A part that must function accurately at sea level might be required to maintain that accuracy on a flight to the moon when the ambient temperature is —240° F. Under these conditions a new metal may be indicated.

Producing metals with low coefficients of expansion under extreme temperatures for dimensional stability and control is part of V-R's everyday activities. If you need a part with this characteristic or possibly one that is highly corrosion resistant . . . or one that has long wearing qualities . . . or one that has to take an extremely fine surface finish . . . then contact V-R.

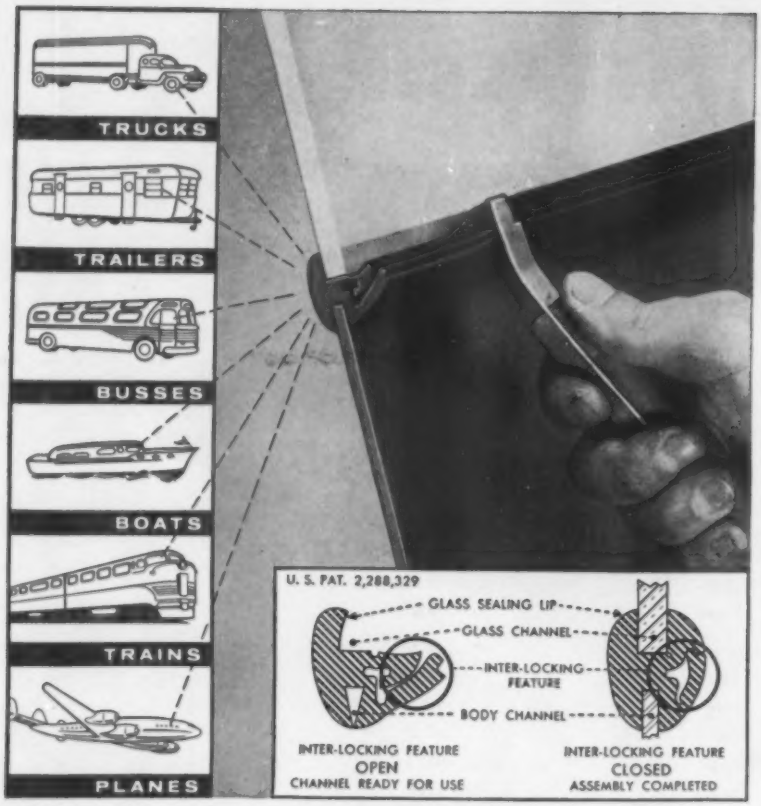
**V-R VASCOLOY-RAMET**

CREATING THE METALS THAT SHAPE THE FUTURE

A-781

844 MARKET STREET • WAUKEGAN, ILLINOIS

For more information, turn to Reader Service card, circle No. 465




## Self-Locking Rubber Channel for Mounting Glass in Body Panels

Its *one-piece* design locks and seals in one operation. No extra locking-strip needed. It's the faster, simpler method for mounting glass in any type body panel—truck, trailer, bus, boat, train, plane, etc.

*Extruded* with inter-locking feature at direct right angle to body, the Continental Channel permits unhampered insertion of glass. Locking tongue is pressed into its matching groove which forces the lips against *both* the glass and body panel—a more positive seal with exceptional push-out pressure.

Compounded for maximum weather resistance and extra long life. Close durometer tolerances are held for uniformly tight seal against moisture and surest possible locking. These rubber channels can be positioned first on *either* glass or body panel. All details are shown in illustrated brochure gladly sent on request.

Ordered and re-ordered by the most prominent body builders, this Self-Locking Channel is another example of the creative thinking and ingenuity behind rubber parts by Continental. When you need rubber parts to do a specific job, call a rubber specialist *during the planning stage.* This often makes for economy as well as better end results. Call Continental —rubber specialists since 1903.

**Engineering catalog.**

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

*Another achievement in* **RUBBER**
*engineered by* **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1985 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 430

bondale, Pa. The perforated metal is called Conidure.

According to the producer, the new product lasts up to three times longer than conventional perforated metal in screening, recovering and dewatering applications. Key to the material's long life: the working side of the perforated metal, which has the smaller end of the tapered openings, has humps that act in a "shovel-like" manner to guide materials such as rocks, stones and gravel to the openings. The humps are also said to prevent clogging.

Perforated metal sheets are supplied in widths up to 31 in. and in thicknesses from 0.014 to 0.079 in.

KEY NO. 617

## Fast Tinning Method for Aluminum Parts

A compound for the immersion tinning of aluminum is said to produce a smooth, adherent tin coating on parts after 4 min immersion in a bath at 165-175 F. Little sludge is formed and there is no need for control of hydroxide content or for acetic acid additions to the bath, according to Allied Research Products, Inc., 4004 E. Monument St., Baltimore 5, Md.

The developer says the bath does not build up excess tin deposits in machined areas. The compound, called ARP No. 200, is supplied in powder form in 25, 100 and 400-lb packages.

KEY NO. 618

## Lubricant Resists Extreme Pressures

A new molybdenum disulfide lubricant is recommended for extreme pressure applications on drills, taps, cold metal forming dies and punches. The lubricant, called Molykote M-55-Plus, is available from Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.

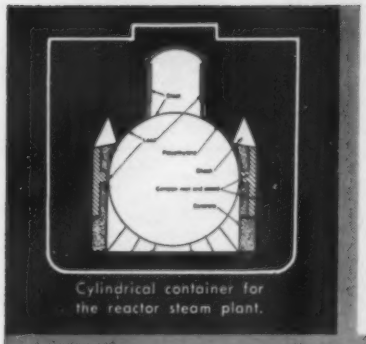
According to the developer, the lubricant does not derive its extreme pressure characteristics from the fusion of additives like sulfur and chlorine at elevated temperatures, as do conventional extreme pressure lubricants. Thus, the lubricant is

# 500 TONS OF LEAD

## *Provide The Shielding In The*

# N. S. SAVANNAH

## *...The World's First Nuclear-Powered Merchant Ship*



Cylindrical container for the reactor steam plant.

The 20,000 ton N. S. Savannah
Speed: 21 knots.
Cruising radius: 350,000 miles.

PB-150

The 20,000 ton N. S. Savannah contains some of the most advanced radiation shielding yet developed. Over 500 tons of lead, along with water, concrete and polyethylene, provides such a high degree of safety to the crew and passengers that a man standing on the main deck will receive no more radiation from the powerful reactor under his feet than he will from the sky.

The cylindrical container for the reactor steam plant is a steel pressure vessel averaging two inches thick. It measures 35 feet in diameter and is 51 feet long. The radiation shield is divided into two parts. The first, which surrounds the nuclear reactor is composed of a shell of water thirty-three inches thick and approximately three inches of lead. The second, which covers the entire containment vessel, is composed of concrete, polyethylene and a shell of lead four to eight inches thick.

Lead is a preferred material for radiation shielding because of its density. Shielding effect against the deadly gamma radiation is directly proportional to the density of the shield, and lead is the densest of all the commonly available materials. It, therefore, provides the best protection per unit of shield thickness at the lowest cost. Thus lead — one of the oldest metals known to man — is a major factor in the rapidly expanding utilization of man's newest discovery, Nuclear Energy.

500 tons of lead in the form of sheets 6x3 feet and 1 or 2 inches thick were preformed to the cylindrical shape with a rolling jig. Spherical end sections were die formed.

*Look Ahead*
*With* ***LEAD***

# ST. JOSEPH LEAD CO.

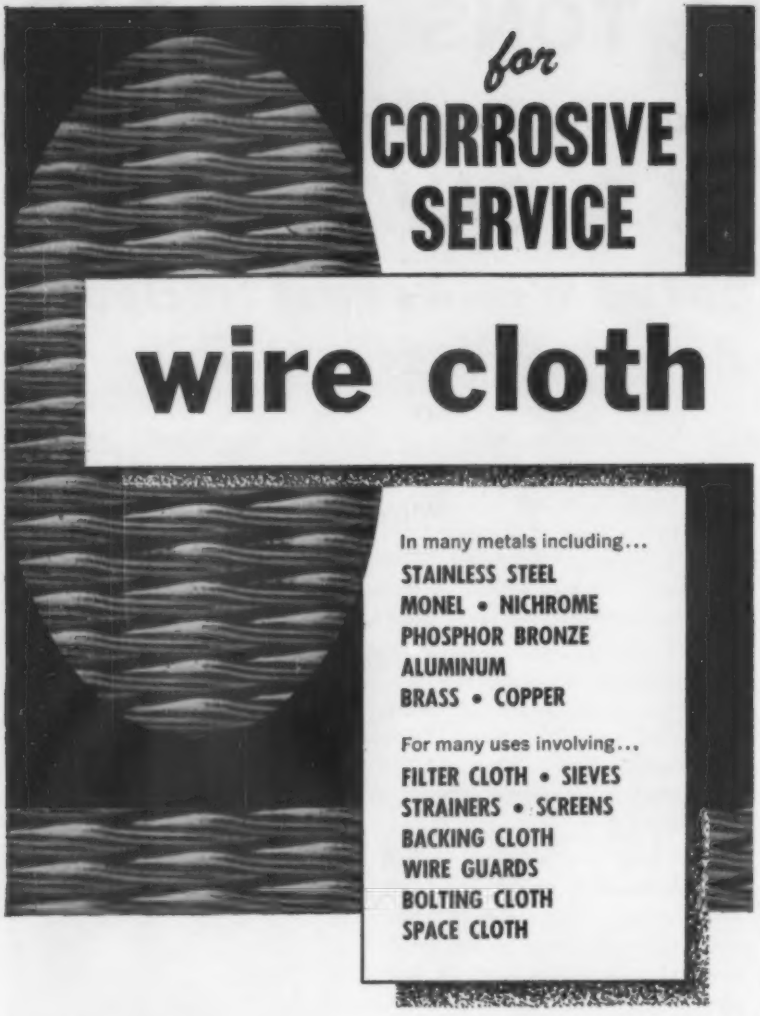
**250 Park Avenue**

**New York 17, New York**

ST. JOE

**THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES**

For more information, turn to Reader Service card, circle No. 363




If you have a tough corrosion problem and need wire cloth or wire cloth parts, here's a source of supply that knows the answers. We are proud of the quality of our cloth...accurate mesh count, close tolerance wire diameter, precision weaving...plus the know-how necessary to specify the proper alloy for your service conditions.

NEWARK for ACCURACY

Write or call us today if you have a problem calling for anti-corrosive wire cloth or wire cloth parts. Send for Bulletin F-C.

**Newark Wire Cloth COMPANY**

351 Verona Avenue • Newark 4, New Jersey

For more information, turn to Reader Service card, circle No. 429

**PROPERTIES OF MOLYKOTE M-55-PLUS**

| | |
|---|---|
| Specific Weight, lb/gal | 7.9 |
| Flash Point, F | 340 |
| Fire Point, F | 390 |
| Viscosity (Saybolt Universal) | |
| 100 F | 530 |
| 210 F | 57 |
| Service Temperature, F | 0-250 |

suitable for slow moving parts under heavy loads, and for surfaces that would be reactive with additives.

The improved lubricity of M-55-Plus, and its ability to plate itself out on metal surfaces, recommends it also for wear reduction applications in sleeve bearings and instrument gears, even though lightly loaded.

The lubricant is a colloidal dispersion of sub-micron molybdenum disulfide particles in mineral oil. Stability tests at different dilutions show that the particles do not settle out after several months exposure to temperatures up to 140 F.

KEY NO. 619

## Large Tungsten Ingots

Oregon Metallurgical Corp., P. O. Box 484, Albany, Ore. is currently producing tungsten-molybdenun alloy ingots weighing over 500 lb.

The ingots, which measure 10 in. in dia. by 14 in. long, are produced by the double melt vacuum arc process. The company says its arc melted ingots are purer and more uniform in properties than tungsten alloy ingots made by sintering.

Although tool wear is high, finished parts can be made by direct machining of the ingots. Good machining rates can be obtained with carbide tools, according to the producer.

KEY NO. 620

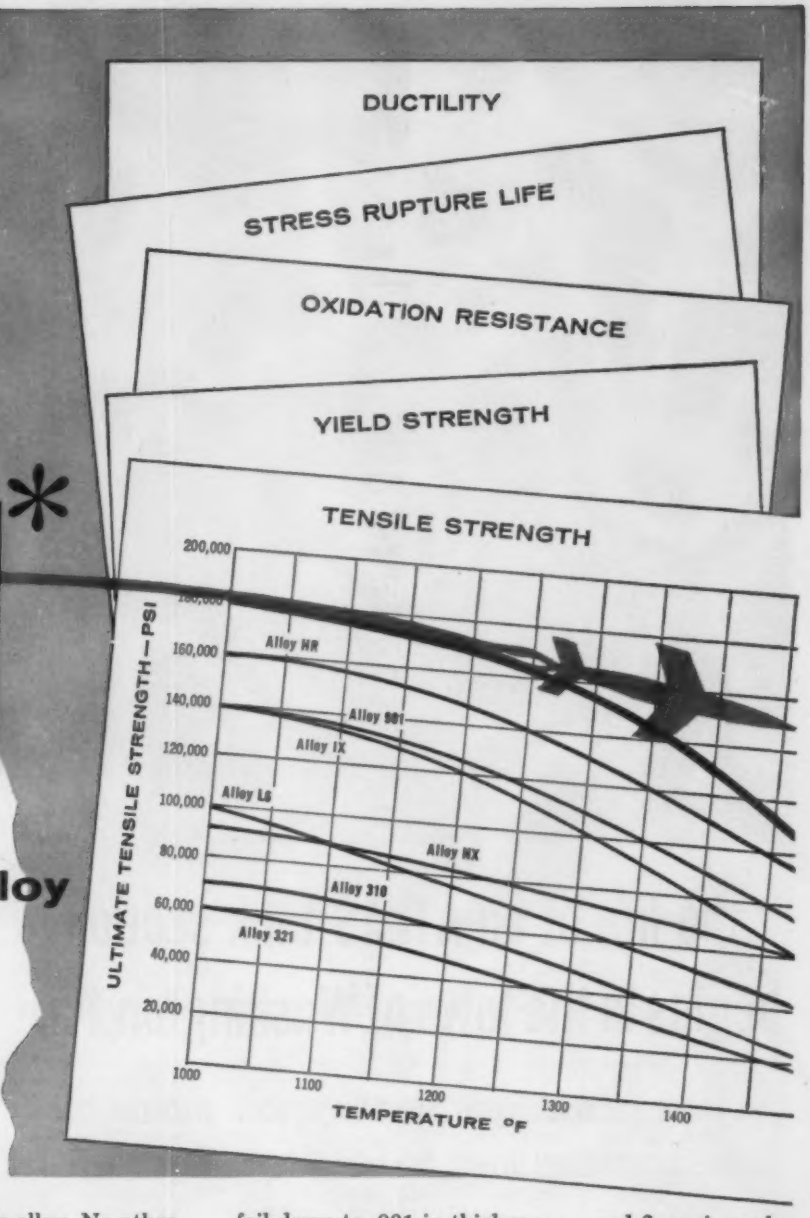
## Glass-Epoxy Laminate Useful up to 350 F

A newly developed glass-epoxy laminate is said to retain its strength at elevated temperatures; for example, a ⅛-in. thick sheet of the material retains at least 68% of its flexural strength after 1-hr exposure at 300 F. The material,

# HIGH on every chart:

# RENÉ 41*

## most dependable alloy in use today in the 1200°-1800°F range




In *all* ways, René 41 is a remarkable alloy. No other high-temperature alloy used in production today equals its tensile strength. In other properties, too, René 41 is far ahead of the field.

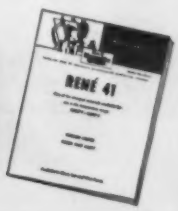
Also important, this nickel-base, vacuum-melted alloy is easy to work with. It's readily formable by drawing, bending, spinning — welds to similar or dissimilar materials.

Cannon-Muskegon offers René 41 in standard 36″x 96″ sheets .015″ to .125″ thick, in smaller sizes down to .010″, in bar stock up to 3″ in diameter... foil down to .001 in thickness... and fine wire only .0015 in diameter.

For complete details, write for Technical bulletin No. 86.

*TM of General Electric Co.

ULTRAMET
VACUUM ALLOYS




## CANNON-MUSKEGON CORPORATION

2873 Lincoln Avenue • Muskegon, Michigan

METALLURGICAL SPECIALISTS

For more information, turn to Reader Service card, circle No. 419

# "the life of an ATLAS tank section begins in the town of Washington, Pa.

## . . . where the Washington Steel Corporation produces thin-gauge Stainless Steel in long, flexible bands about a yard wide."*

Washington Steel Corporation is the exclusive supplier of stainless skin for the ATLAS program for a very good reason: it has been able to meet the exacting specifications laid down for this specific undertaking.

Washington Steel Corporation is the pioneer in precision-rolling of light gauge stainless sheets by the Sendzimir process.

*ATLAS—The Story of a Missile
*by John L. Chapman,* ©1960

**WASHINGTON STEEL CORPORATION**
4-F WOODLAND AVENUE WASHINGTON, PA.

For more information, turn to Reader Service card, circle No. 441


## What's new IN MATERIALS

**PROPERTIES OF GEC-111 LAMINATE**

| | |
|---|---|
| **PHYSICAL PROPERTIES** | |
| Specific Gravity | 1.80 |
| Max Cont Svc Temp, F | 350 |
| Water Absorption (24 hr), % | 0.20 |
| **MECHANICAL PROPERTIES** | |
| Tensile Strength, psi | |
| Lengthwise | 45,000 |
| Crosswise | 40,000 |
| Flexural Strength, psi | |
| Lengthwise | 60,000 |
| Crosswise | 50,000 |
| **ELECTRICAL PROPERTIES** | |
| Insulation Res (cond C96/35/90), megohms | 350,000 |
| Dielec Str (par., step-by-step), kv | 45.0 |
| Dissipation Factor (1 mc) | |
| Cond A | 0.020 |
| Cond D24/23 | 0.030 |

which can be used continuously at temperatures up to 350 F, was developed by Taylor Fibre Co., Norristown, Pa. It is called GEC-111.

According to the producer, printed circuit boards made from GEC-111 copper-clad laminates will not distort when placed in hot solder baths. The material has a low dielectric loss and good insulation resistance after exposure to high humidity.

The laminate is furnished in sheets in thicknesses ranging from 0.010 to 1 in. It is also furnished as a copper-clad laminate, either with rolled copper foil (GEC-111R) or with electrolytically deposited foil (GEC-111E). KEY NO. 621

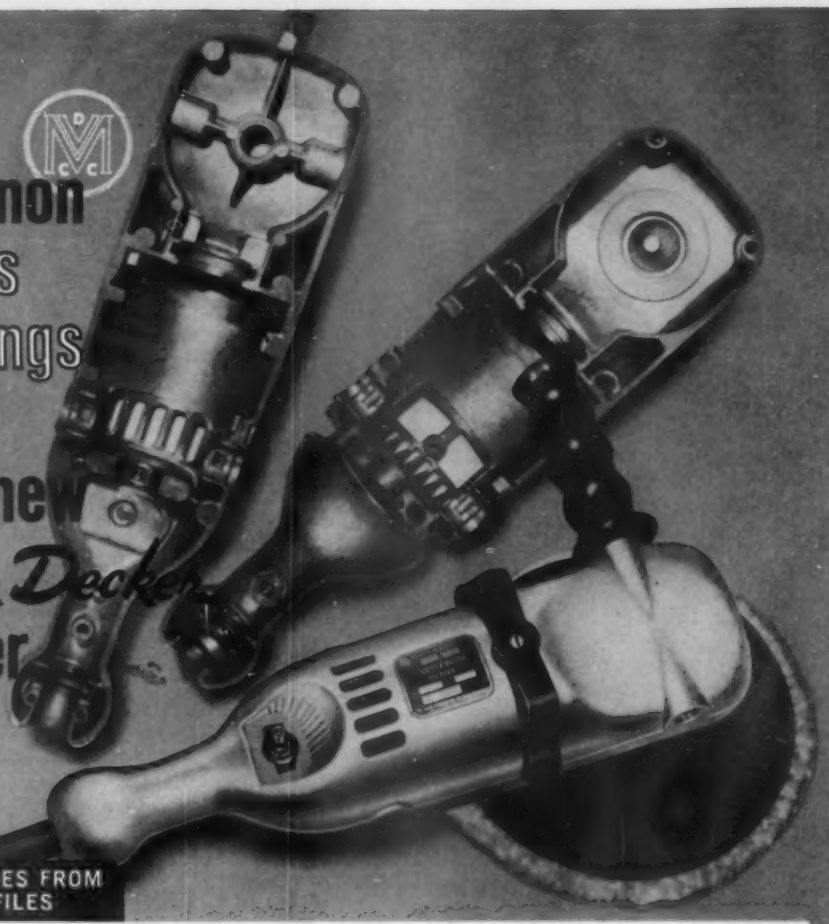
## Six Plastics Films Designed for Packaging

Six new and improved plastics films are now available for a wide variety of packaging applications. The films, made of such plastics as nylon, polyethylene and cellophane, are said to have good moisture resistance, high tear strength and long shelf life.

### Nylon film

Extruded nylon film in thicknesses ranging from 0.002 to 0.060 in. and in widths up to 18 in. is now available from United States Gasket Div., Garlock Packing Co., Camden 1, N. J. according to the producer, the material is grease, abrasion and

# Mt. Vernon reduces 5 castings to 2 in the new Black & Decker Polisher



CASE HISTORIES FROM MT. VERNON FILES

**Subject:**

## The Black & Decker Manufacturing Company, TOWSON, MARYLAND

This new B & D "Servicemaster" Polisher—and its companion Sander, each of which sells for only $65. —contains outstanding features formerly found only in higher priced units: heavy-duty ball bearings; spiral bevel gears; recessed toggle switch, protected from dust; rugged lightweight aluminum housings.

Advanced design, which took into consideration most of the inherent advantages of high-pressure aluminum die casting, resulted in considerable manufacturing economies and an ultimate *low price tag*.

Conventional design on the regular B & D line uses 5 castings: 1-a gear case 2-a gear case cover 3-a main field case 4-a switch handle 5-a switch handle cover. In the new B & D design concept *5 parts have been combined into 2 clam-shell castings* which weigh only 2 pounds 3 ounces, a weight reduction of approximately 2 pounds over similar type polishers... the new complete "Servicemaster" polisher weighs only 8¼ pounds.

Fewer parts, however complex, mean reduction in secondary assembly operations. But despite intricate design...the superior skill of Mt. Vernon craftsmen has assured Black & Decker a steady supply of highest quality aluminum castings, economical, excellent fitting...excellently finished...requiring the least number of finishing operations.

Perhaps, like Black & Decker, you too have a cost problem. Product design with our assistance may be your answer. Let's talk it over. Just call your nearest Mt. Vernon sales representative for action.

**MT. VERNON DIE CASTING CORPORATION**
STAMFORD, CONNECTICUT

**SALES REPRESENTATIVES**

BALTIMORE, MD.: Mr. C. M. Gordan, 919 St. Paul St.
BROOKLYN, N. Y.: Mr. Robert V. Moore, 2317 Plumb 2nd St.
CLEVELAND, OHIO: Mr. Grant Eller, 6 East 194th St.
GUILDERLAND, N. Y.: Mr. David H. King, 75 Willow St.
PITTSBURGH, PA.: Mr. Andrew W. Anderson, 300 Pasadena Drive So.
QUINCY, MASS.: Mr. Edmund W. Libby, 91 Merrymount Rd.
ROCHESTER, N. Y.: Mr. William Sauers, 101 Briarcliff Rd.
SKANEATELES, N. Y.: Mr. Jerome J. Theobald, 9 E. Genesee St.
STAMFORD, CONN.: Mr. Anker Anderson, Cascade Road
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115

For more information, turn to Reader Service card, circle No. 440

A—Refrigerant receiver—6″ x 48″
B—Air die cushion receiver—8″ x 20″
C—Air brake and air clutch receiver—10″ x 30″
D—Dental compressor receiver—16″ x 13″

# Hackney air receivers...made to your specifications for any service

Whatever your special requirements or standard applications, your Hackney air receivers will meet all code requirements. And they'll be made two-piece, with *one* weld uniting the deep drawn sections into a strong, lightweight receiver.

Standard Hackney air receivers, horizontal model, are available in capacities of 30, 60, 80 and 120 gallons; vertical models, in 60- and 80-gallon sizes. Specially designed receivers for refrigerants or compressed air vary in capacity with their specifications.

For complete information on Hackney air receivers, write today.

**Pressed Steel Tank Company**
*Manufacturer of Hackney Products*
1442 South 66th Street, Milwaukee 14, Wisconsin
Branch offices in principal cities
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 453

## What's new IN MATERIALS

vapor resistant; has a low coefficient of friction and a low permeability factor; and can be steam sterilized.
KEY NO. 622

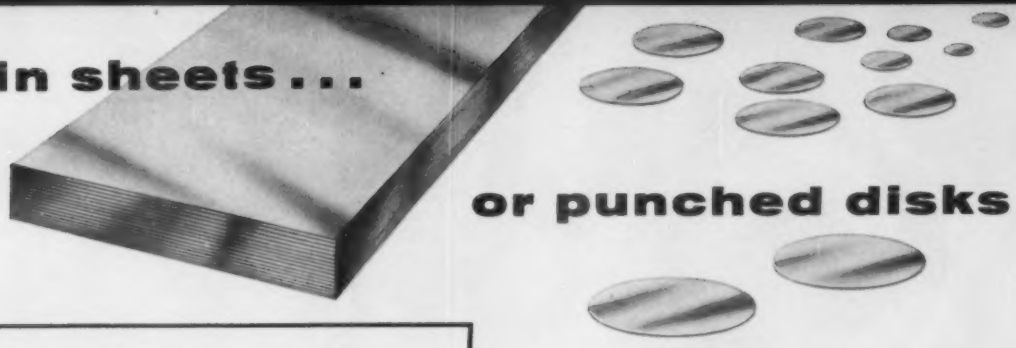
**Polyethylene film**

Two film-grade polyethylene resins ranging in density from 0.940 to 0.960 gm per cu cm have been introduced by W. R. Grace & Co., Polymer Chemicals Div., 225 Allwood Rd., Clifton, N.J. One is a type II, or intermediate density, resin (0.940 gm per cu cm) designed for overwrap applications. Film made from the resin is said to have good clarity, long shelf life and good moisture resistance. The other film-grade resin is a type III, or higher density, resin (0.960 gm per cu cm) intended for extrusion into heavy-gage film or sheet (4 to 10 mils

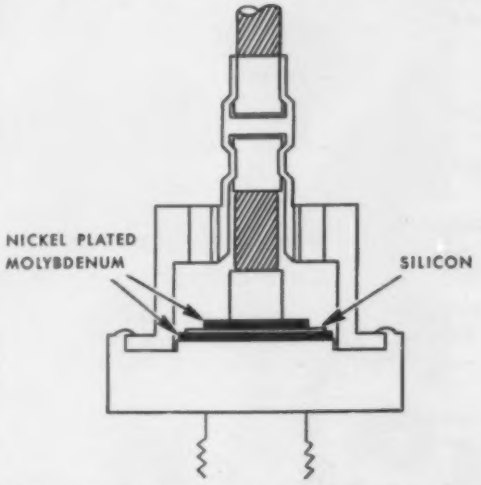
**Stretch forming aid**—The worker shown above holds a curved, stretch formed extrusion (left) made with the aid of a new filler "snake" called Hobe. According to the developer, Hexcel Products, Inc., 2332 4th St., Berkeley, Calif., the snake can be used in stretch forming almost any contoured metal part. Previously used filler snakes did not conform well to a curved surface. The new product is made up of thousands of strips of 0.005-in. thick aluminum foil stacked and secured to one another to form a snake of any size. Current price ranges from 30 to 80¢ per cu in., depending on complexity of cross section. Currently its chief use is in the manufacture of structural components for aircraft and missiles. KEY NO. 623

*Another New Fansteel Service*

# ...NICKEL PLATED MOLYBDENUM




## Ideal for Silicon Rectifiers




Fansteel nickel plated molybdenum provides these ideal qualities required in backing plates for silicon: (1) close match to silicon in coefficient of linear expansion, (2) low electrical resistivity, (3) good workability, (4) easily soldered and (5) low cost.

Fansteel's continuous program of new ideas, new products and new services now brings you famous Moly "D", *nickel-plated* for easier wetting in soldering operations. Nickel plated molybdenum promises particular advantages in such areas as backing plates in silicon rectifiers.

Because Fansteel molybdenum is plated with extreme care under strict quality control, the nickel plate has a tight adherence . . . will not flake or tend to separate in blanking operations . . . and provides excellent conductivity in electrical and thermal applications.

Moly "D" sheets can be supplied plated either on one side or both sides, and punched disks are available in a wide range of sizes.

For complete information, call or write your Fansteel representative or Fansteel direct . . . Metals and Fabrications Division.

FANSTEEL

**FANSTEEL METALLURGICAL CORPORATION**

NORTH CHICAGO, ILLINOIS, U.S.A.

K603

For more information, turn to Reader Service card, circle No. 486

Complex *INTERNAL* Design
Unified in *CAST STEEL!*

**UNITCASTINGS provide answer for difficult parts problem!**

Again, Unitcast Foundry Engineering proved invaluable in producing this hydraulic valve body casting.

Faced with the necessity of a durable, more compact unit, the customer investigated the advantages of *cast steel*. Firm specifications included small and irregular internal passages that were impossible to machine blind. Tolerances were close and exceptionally clean internal surfaces were a necessity. Shell cores, as illustrated, were used in a green sand mold. The system was streamlined and the more compact unit did not hamper the mechanism. Costs were reduced to a fraction of the alternate composite machined assembly.

Unitcastings can possibly meet your unusual problems, too. Why not investigate today . . . call for a Unitcast Sales Engineer.

UNITCAST CORPORATION, Toledo 9, Ohio
*In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec*

**Unitcast**

**SPECIFICATION STEEL CASTINGS**

For more information, turn to Reader Service card, circle No. 467




thick). According to the developer, the resin can be readily decorated by a number of processes such as offset lithography. **KEY NO. 624**

Union Carbide Plastics Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17 has introduced two new type II resins for film extrusion. The materials, designated DHDA-6150 and DHDA-6151, are recommended for extrusion into films that will be subsequently used in automatic packaging machines. Carbide's DHDA-6150 resin is recommended for extrusion into very thin films (0.3 mil), and DHDA-6151 for heavy-gage film (0.75 to 1.25 mil). Both materials are said to extrude into high clarity films. **KEY NO. 625**

### Cellophane film

A polymer-coated, heavy-gage cellophane film introduced by E. I. du Pont de Nemours & Co., Inc., Film Dept., Wilmington 98, Del. is said to have good durability. In a durability test conducted at 0 °F and 20% RH, the 600-gage film scored 93% on durability against 38% for double-wall 300-gage cellophane films. The new heavy-gage cellophane film, called 600-K, is said to provide adequate moisture protection on most items. **KEY NO. 626**

## Damping Material Cuts Vibration by 90%

Vibra-Check is the name given to a new vibration damping material designed for air conditioners, laundry equipment, business machines, and metal-working machinery. The supplier, Lowell Industries, Inc., Allston Sta., Boston 34, says actual service conditions have proved the material will eliminate up to 90% of vibration in various types of machinery.

The product is easy to install and does not require cementing. A vacuum suction cup pattern on the surface of the material makes it conform to rough or uneven surfaces.

Vibra-Check is made by bonding two layers of a tough vinyl chloride elastomer to both sides of a strong reinforcing core of monofilament fiberglass. The finished product has three layers of material with different natural frequencies. The resi-

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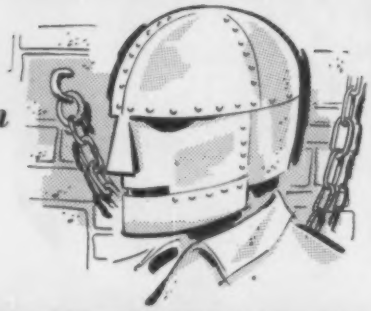

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## What's new IN MATERIALS

lient outer layers have a low density, and the hard central core has a high density.

The vibration damping material is supplied in sheets measuring 22 by 23 in. It can also be furnished cut to size.

(For information on vibration damping shapes of aluminum, see p 10). KEY NO. 627

### Metal Spray Powder for Worn Crankshafts

An easy-to-apply metal spray powder for rebuilding worn engine and compressor crankshafts is now available from Wall Colmonoy Corp., 19345 John R St., Detroit 3. The material, called Colmonoy C-290, is applied with a flame spraying unit, then finish ground. The resulting metal spray overlay is said to have a low coefficient of friction and good oil retention qualities. The metal spray powder contains chromium, nickel and chromium borides.

KEY NO. 628

### High Strength Steel Not Notch Sensitive

Universal-Cyclops Steel Corp., Bridgeville, Pa. recently announced the availability of Unimach UCX2, a cobalt modification of the AISI 4100 series type of steel. According to the developer, tests show the new steel is essentially not notch sensitive in the 225,000-235,000 psi yield strength range.

*Properties, composition*—The accompanying graph shows room temperature properties after tempering at various temperatures. A typical analysis of UCX2 is: C, 0.39; Mn, 0.70; Si, 1.00; Cr, 1.10; Mo, 0.25; V, 0.15; Co, 1.00.

*Heat treatment*—UCX2 should be heated slowly and uniformly to forging temperature (minimum: 1850-1950 F). Final working should not be below 1650 F. Forgings must be cooled slowly. The best machinability is developed by normalizing from 1700 F, then tempering 2 hr at 1250 F.

Optimum properties are obtained by austenitizing at 1700 F and double tempering at 500-600 F. Austeni-

The products illustrated are made by The Animal Trap Co., Lititz, Pa., a regular user of Bethlehem wire.

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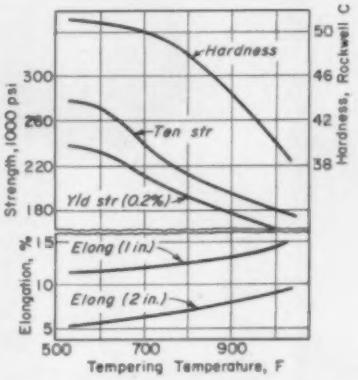
## What's new IN MATERIALS




***Room temperature** sheet tensile mechanical properties of UCX2. Specimens austenitized at 1700 F and double tempered at temperatures shown.*

tizing time will depend on section size. Universal-Cyclops recommends 20 min for sections ½ in. or less. Over ½ in., time should be figured on the basis of 1 hr per in. of section size.

Annealing consists of heating to 1440 F ± 20 F, holding 2 hr, fast cooling to 1250 F ± 15 F, holding 14-24 hr and then air cooling to room temperature.

*Machinability, fabrication*—UCX2 can be readily machined in the annealed condition. As heat treated, machinability is similar to that of AISI 4140.

The alloy can be deep drawn, rolled into rings, hydrospun and peened as readily as other 4100 steels.

Automatic tungsten arc inert gas welding has been successfully used to join UCX2 sheets. **KEY NO. 629**

## Polyethylene Powders for Coating, Molding

Two types of finely divided polyethylene powders are commercially available from U. S. Industrial Chemicals Co., Div. of National Distillers and Chemical Corp., 99 Park Ave., New York 16. The powders, called Microthene, are suitable for use as coatings on various types of materials, and for molding large shapes.

One powder is a Type I, lower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X-ray of a one-quarter inch thick beryllium weldment.

## THE BRUSH BERYLLIUM COMPANY

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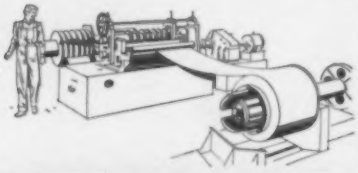

ENGINEERING YODER MANUFACTURING ROTARY SLITTING LINES

For more information, circle No. 334


## What's new IN MATERIALS

density (0.916 gm per cu cm), high melt index (22 gm per 10 min) material. The other powder is a Type II, medium density (0.924 gm per cu cm), medium melt index (5 gm per 10 min) material.

Each powder is made by two different processes—a solution technique and a mechanical grinding method. Both methods, details of which have not been revealed, were developed in Europe. The solution technique yields very small particles (<200 mesh); the machanical grinding method produces larger particles (50 to 200 mesh).

Introductory prices are 65¢ per lb for the finer size powder and 40¢ per lb for the coarser powder.

**Potential applications**

According to the producer, textile coating will probably be one of the large potential markets for Microthene finely divided polyethylene. Some of the uses expected: coatings for all types of textiles including

**Large nylon shapes**—Large nylon shapes such as those shown here are expected to open up new applications for the material, such as tooling fixtures, wear plates and large rollers. The shapes, weighing up to 400 lb and measuring 36 in. wide by 2⅝ in. thick by 102 in. long are being produced by Polymer Corp., 2120 Fairmont Ave., Reading, Pa. The company is presently offering the new shapes in limited quantities, but will soon make them available on a production basis.

KEY NO. 630


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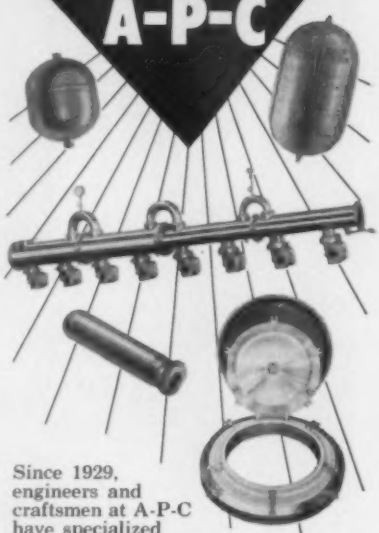

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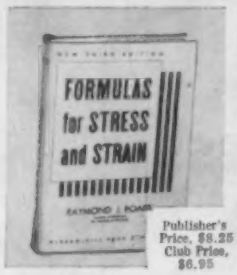


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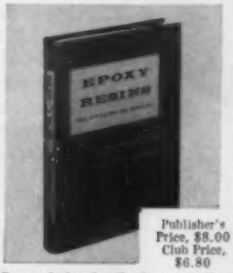


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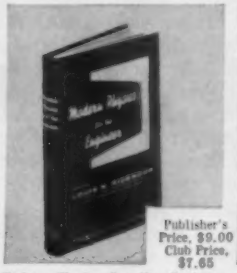

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What's new IN MATERIALS

nonwovens; binders for nonwoven fabrics; and stiffening agents for specialized textiles.

Metal coating is another large potential market. Shipping drums, metal sheet and a variety of metal parts can be coated for protection against corrosion. Paper, wire and glass coatings are other applications that show promise.

Extremely large moldings, particularly drums and tanks, can be made with finely divided polyethylene. Regular or irregular shaped products can be formed in inexpensive molds by using fusion molding techniques, such as the ones described in the Mar '60 issue of this magazine (p 11).

**Methods of application**

Coatings of the new material can be applied as a powder by fluidized bed techniques, as a dispersion in water or alcohol, or as a paste.

KEY NO. 631

## Molybdenum Arc Cast into Hollow Shapes

More information on the direct casting of molybdenum into hollow shapes, as reported in the Feb '59 issue of this magazine (p 4), has recently been made available by the Bureau of Mines, Dept. of the Interior, Washington, D. C. The information is contained in Report No. 5555, prepared by E. D. Calvert, S. A. O'Hare and A. H. Roberson.

**Arc cast tubes can be made on a production basis**

Calvert and his associates say that structurally sound centrifugally cast molybdenum tubes can be made on a production basis with vacuum arc melting and casting techniques. However, more research must be done before static castings with acceptable surface appearance and internal soundness can be produced by vacuum arc casting. Usually hollow forms of molybdenum are made by powder metallurgy techniques.

Two centrifugally cast tubes and two multiple static castings were made at the Bureau by following vacuum arc melting and casting practices established for titanium, zirconium and hafnium.

**Arc current important**

The basic differences between cast-

No. 12 of a series

## Eastman 910 Adhesive solves another production bottleneck

Electronic Associates, Inc., of Long Branch, N. J., makes PACE analog computers for industrial and military use.

By using adhesive bonding in place of bracket-mounting, its design engineers achieve simpler, faster, space-saving emplacement of 10 electrical relays in each of the several digital attenuator units associated with the computer.

One drop of Eastman 910 Adhesive quickly bonds each aluminum relay case directly to a phenolic potentiometer cover plate, eliminating mounting brackets. Wiring is reduced, too.

Eastman 910 Adhesive was selected because it "was cleaner than other adhesives, resists vibration, does the job, and sets quickly."

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. When spread into a thin film between two surfaces, light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

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For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9104 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. E-4, Kingsport, Tenn. (Not for drug use)
*See Sweet's 1960 Prod. Des. File, 7/E*

For more information, circle No. 384

# a Reminder

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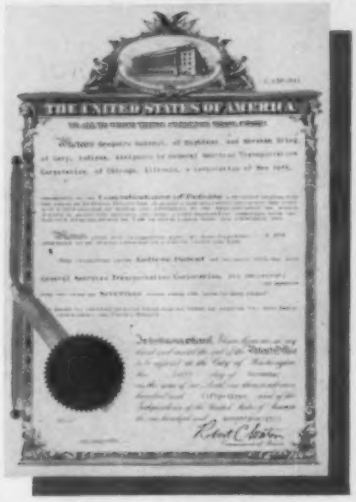


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Is The Answer To Your Dimensional Growth Problems

This table shows the high tensile strength obtainable for iron-copper-structural parts:

| Sintering Conditions | Copper Content % | Sintered Density GRM/cc | Dimensional Change From Tool Size %/inch | Tensile Strength p.s.i. |
|---|---|---|---|---|
| TEMP: 2050°F TIME: 45 Mins. ATMOS: Hydrogen | 0 | 5.8 | —0.25 | 18000 |
| | 3 | 5.8 | —0.10 | 27000 |
| | 5 | 5.8 | +0.20 | 36000 |
| | 7 | 5.8 | +0.30 | 40000 |
| | 10 | 5.8 | —0.01 | 42000 |

In addition to these properties NIAGARA IRON offers you:
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What's new IN MATERIALS

**PROPERTIES OF ARC CAST MOLYBDENUM**

| | |
|---|---|
| Density, lb/cu in. | 0.368 |
| Elec Res (75 F), microhm-cm | 5.39 |
| Tensile Strength, psi | 39,800 |
| Yield Strength (0.1% offset), psi | 35,300 |
| Elongation, % | Nil |
| Reduction of Area, % | Nil |
| Impact Str (Charpy), ft-lb | 2 |
| Hardness (Rockwell A) | 49 |

ing molybdenum and casting other reactive metals were in the control of major variables such as arc current, arc potential and coolant flow. To cast molybdenum, the researchers recommend an arc potential of 36 to 40 v with a current of 10,000 amp d.c. for a pouring crucible 10 in. in dia.

According to the researchers, the centrifugally cast tubes were easy to remove from molds, and visual observation indicated no metal-mold reaction. The interior surface of the cast tubes was clean, bright and fairly smooth.

**Properties**

Tests showed that centrifugally cast molybdenum tubes have physical and mechanical properties similar to those of unworked hollow shapes produced by powder metallurgy techniques. Properties of cast molybdenum are given in an accompanying table.

Radiographic examination showed that the vacuum arc cast tubes have no porosity or casting defects, and have no variation in density from end to end.

## Two Brighteners for Zinc Electroplates

Two brightening agents for zinc electroplates have been introduced by Allied Research Products, Inc., 4004 E. Monument St., Baltimore 5, Md. Both are supplied in liquid

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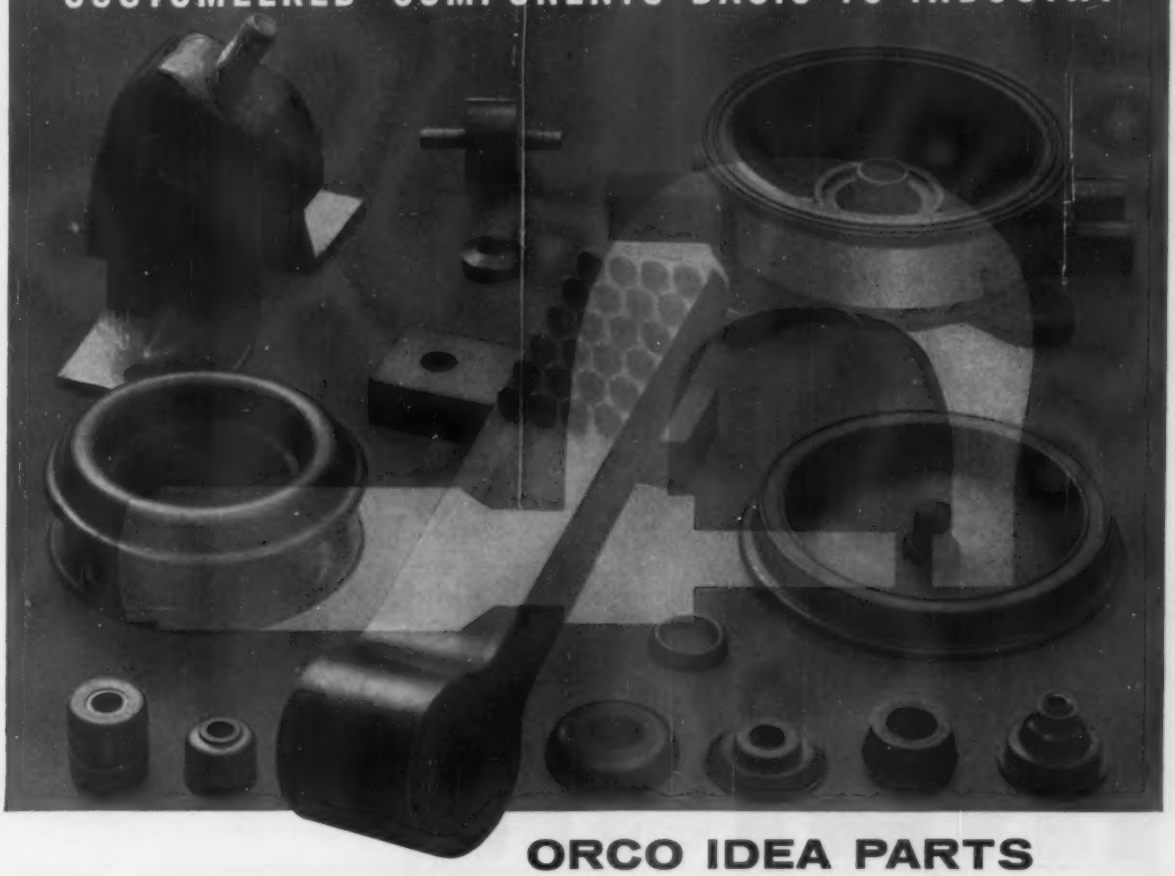

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form. They are said to be extremely stable, providing effective brightening after weekend shutdowns.

*Isobrite No. 354* is said to produce a white, bright zinc electroplate without bright dipping. The compound is recommended for use in barrel plating equipment.

*Isobrite No. 355* is said to produce a bright zinc deposit with a slight yellow cast. The deposit becomes clear and sparkling after bright dipping. The compound is recommended for use in barrel plating equipment and in tanks. KEY NO. 632

## Tapes for Electrical, Chemical Applications

Two new tapes — one made of mica, glass cloth and polyester film, and the other of TFE resin—are now on the market. The mica tape is recommended for electrical applications; the TFE tape is recommended for chemical pipelines and hydraulic equipment.

**1. Mica tape**

The mica mat insulating tape requires neither varnish nor bake treatment during application. The tape, developed by General Electric Co., Schenectady 5, N. Y., uses four-layer construction that sandwiches ribbons of mica mat and glass cloth between two outside films of polyester insulation.

Tests show that the dielectric strength of the new tape is about 30% higher than that of commonly used mica paper tapes, and more than 50% higher than that of organic-bonded, built-up mica tapes. The new tape is also said to have good tensile strength and unlimited shelf life. KEY NO. 633

**2. TFE tape**

The TFE tape was developed by Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn. The pressure sensitive tape, known as Temp-R-Tape FR, is said to be resistant to such fuels as JP-4 jet fuel and ASTM Reference Fuel B, as well as a large group of chemicals such as tri-n-butyl phosphate.

The TFE tape is designed for use where the combination of high temperature and chemical resistance is necessary. Suggested areas of application are engines of all types, hydraulic equipment, chemical pipelines and electrical parts. The tape has a useful temperature range of –50 F to over 400 F. It has a dielectric strength of 1600 v per mil. KEY NO. 634

## Clad Tubing Has High Thermal Conductivity

Two new types of clad metal tubing are designed for use in heat exchangers, and for conduction of fluids and gases under pressure at high temperatures. In one case seamless copper tubing is clad with chromium-nickel grade, austenitic stainless steel; in the other case seamless stainless steel tubing is clad with oxygen-free, high conductivity (OFHC) copper. Ratios of cladding to tubing are 20:80, 30:70, 40:60 and 50:50.

Both types of tubing are available from Metals & Controls Co., Div. of Texas Instruments Inc., 34 Forest St., Attleboro, Mass.

According to the producer, a clad tube containing equal volumes of copper and stainless steel has a lateral thermal conductivity 3½ times that of a solid nickel tube, and 12¼ times that of a solid stainless steel tube of the same physical dimensions.

The clad seamless tubing can normally be supplied in the annealed or as-drawn condition in the following sizes: 0.030 to 0.750 in. o.d., 0.003 to 0.045 in. wall thickness, and lengths up to 12 ft. KEY NO. 635

## Fluoroelastomer Now Easier to Process

Significant improvement in the workability of a new fluorolastomer called Fluorel introduced last spring (see M/DE, May '59, p 152) has been announced by Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

According to the producer, the new version has a Mooney scorch rating almost three times that of the original product, which is said to be in the ideal range for rubber processing. The improved elastomer cures fast, and the cured rubber has good heat aging properties at temperatures above 400 F.

Applications for Fluorel elastomer to date have included o-rings, gaskets and seals for high temperature

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# Characteristics of typical Raybestos-Manhattan Ray-BOND Adhesives

| NUMBER | TYPE | CHARACTERISTICS | USES |
|---|---|---|---|
| R-81001<br>R-81002<br>R-81114 | Thermosetting synthetic rubber, synthetic resin; heat setting. Solids range from 18 to 34%. | Flexible, resistant to oils, solvents; requires heat and pressure for cure. | For bonding metals, plastics, friction materials to themselves or to each other. Not recommended for use on assemblies where bond line temp. might exceed 400°F for prolonged periods in application. |
| R-82004 | Synthetic rubber, synthetic resin; emulsion adhesive; cold setting; solvent evaporation type. | Flexible, good peel strength, medium drying; gains strength upon loss of solvent; exhibits good strength up to 270°F for nonstructural applications. | General purpose adhesive for nonstructural parts. |
| R-82005<br>R-82006<br>R-82007<br>R-82008 | Synthetic rubber, synthetic resin; solvent evaporation type. Solids range from 17 to 30%. | Flexible, good peel strength, quick drying; gains strength upon loss of solvent; not to be used on parts that might be subjected to temperatures in excess of 180°F; sprays well. | General purpose adhesive for nonstructural parts. |
| R-84001 | Synthetic resin; hot melt type. | Flexible, to be heated to 250-300°F and applied. Strength obtained upon cooling. | General purpose adhesive for bonding most materials including mylar and polyethylene. Recommended as a nonstructural adhesive for applications where the bond line temperature will not exceed 150°F. |
| R-84029 | Synthetic resin; heat setting. | Heat resistant to 650°F; some degree of flexibility; resistant to oils, solvent, water, brake fluids. | Friction material to friction material or to steel where some degree of flexibility is desired. |
| R-86005 | Synthetic resin; 2-component system. | High tensile strength, room temperature curing; salt spray, hydraulic oil, JP-4 fuel resistant. | Metal-metal, ceramic-metal, glass-metal. |
| R-86008 | Synthetic resin; 2-component system. | Good electrical properties, low shrinkage. Heat distortion point of 178°F. Pot life 30 min. | Casting, encapsulating and potting. Metal-metal, ceramic-metal, glass-metal. |
| R-86044 | Special synthetic resin base; 2-component system. | Room temp. curing; 40 min. working life. | Bonding etched Teflon to metal, glass to glass, where optimum chemical resistance is desired. |
| R-87001 | Synthetic rubber base. | Good adhesion; high peel strength up to 270°F; contains no flammable solvents. | Fabrics to fabrics. |
| R-86020 | Special synthetic resin; single component system. | High tensile strength; excellent resistance to most chemical acids and alkalies. Heat resistant to 400°F; unlimited pot life. | Metal-metal, ceramic-metal, metal-plastics. |

## RAYBESTOS-MANHATTAN manufactures these 7 classes of adhesives, coatings and sealers:

1. Heat setting, synthetic resin adhesives, coatings, and sealers (not epoxy)
2. Cold setting, synthetic resin adhesives (not epoxy)
3. Heat setting, synthetic resin, synthetic rubber adhesives
4. Cold setting, synthetic resin, synthetic rubber adhesives
5. Rubber base adhesives
6. Synthetic resin sealants, and coatings (not epoxy)
7. Epoxy base adhesives, coatings and sealers; casting, encapsulating and potting compounds

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R/M Bulletin No. 700 contains helpful engineering information on Ray-Bond adhesives, protective coatings and sealers. Write for your free copy.

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# ASBESTOS:

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**by D. V. ROSATO**

*Assistant Plant Manager*
*Research Division, Plastics Plant*
*Raytheon Manufacturing Co.*

**1959, 224 pages, $5.75**

The author compiles and presents all available data on the properties and applications of asbestos, including recent advances. The book identifies the broad usage of asbestos in many engineered products. It serves as a convenient guide to various branches of industry including research and development groups, manufacturers, engineering schools, market research groups, and sales management. In addition to acquainting industry with asbestos products in a great variety of fields, the book also reviews the types of asbestos material available, their properties, and methods of manufacturing to further the understanding of the variables which exist in handling asbestos.

CONTENTS: Industrial Applications of Asbestos; Properties of Asbestos; Asbestos-Cement; Tile; Asbestos Heat Insulation; Asbestos Electrical Insulation; Asbestos Friction Materials; Asbestos Textiles; Plastics; Asbestos Packings and Gaskets; Asbestos Filters; Other Products; Census on Asbestos Products; Bibliography; Index.

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systems conveying acids, solvents, bases, oils and fuels.

The cured elastomer meets military specification MIL-R-25897A which requires a tensile strength that does not decrease more than 35% after aging 16 hr at 600 F.

The improved fluoroelastomer sells for $10 per lb. **KEY NO. 636**

## Other News . . .

### Metals

▸ Gold, silver, platinum and rare earth metal rod, wire, sheet and special shapes are commercially available from Consolidated Reactive Metals, Inc., 115 Hoyt St., Mamaroneck, N. Y. **KEY NO. 637**

▸ Anodized aluminum strips for electrical windings are being marketed by United Mineral & Chemical Corp., 16 Hudson St., New York 13. The strips are supplied in thicknesses from 0.002 to 0.06 in., in widths up to 12 in. **KEY NO. 638**

▸ Square and rectangular structural steel tubing in a wide range of sizes is available from Espro Tubing Div., Union Asbestos & Rubber Co., 332 S. Michigan Ave., Chicago. Sizes of square tubing range from 3 by 3 in. to 12 by 12 in., and rectangular tubing from 4 by 2 in. to 14 by 10 in. **KEY NO. 639**

### Plastics

▸ An epoxy repair kit for making "on the spot" repairs to pipes, tanks, valves and machinery has been introduced by Carboline Co., 32 Hanley Industrial Ct., St. Louis 17. The kit is called Carbo Fix. **KEY NO. 640**

▸ Three low-molecular-weight polyethylene resins have been introduced by Eastman Chemical Products, Inc., 260 Madison Ave., New York 16. Types LVE and HDE are emulsifiable resins for use in polishes and paper coatings. Type HD is a non-emulsifiable resin for use in printing inks. **KEY NO. 641**

▸ A fiberglass-reinforced polyester molding compound has been developed by Plumb Chemical Corp., 4837 James St., Philadelphia 37. The premixed compound is called Fibercore No. 1200. **KEY NO. 642**

▸ A TFE tape with low shrinkage is available from Dixon Corp., Burnside St., Bristol, R. I. The tape is specified to show no more than 2% change in any dimension when heated to 730 F for 15 min. **KEY NO. 643**

### Other nonmetallics

▸ A new ram mix with a tabular alumina base and an alumina content of 98% has been introduced by Plibrico Co., Refractory Div., 1800 N. Kingsbury St., Chicago 14. The heat setting material, known as Pli-Tab, is designed for use in induction melting steel furnaces and vacuum melting aluminum furnaces. Temperature service range extends from 500 to 3500 F. **KEY NO. 644**

▸ An all-purpose grease called Amalie is available from L. Sonneborn Sons, Inc., 300 Park Ave. South, New York 10. The grease, made from high quality lubricating oils, chemical additives and a gelling agent, is recommended for use in wheel bearings, water pumps and universal joints. **KEY NO. 645**

▸ American Felt Co., 2 Glenville Rd., Glenville, Conn. has developed a vibration damping felt for "hi-fi" and "stereo" sound systems. Called F13, the felt is available in sheets or rolls ⅜ in. thick. **KEY NO. 646**

### Finishes

▸ Gacote NA-62 is the name given to a new, low cost neoprene-asphaltic coating marketed by Gates Engineering Co., Wilmington 99, Del. The material can be used as a coating on underground pipes and as an interior coating on tanks that hold salt water and mild chemical solutions. **KEY NO. 647**

▸ Mitchell-Bradford Chemical Co., Wampus Lane, Milford, Conn. has introduced a new black oxide finishing compound for steel. The product, designated Activated Black Magic, is said to blacken many types of hardened steels which heretofore were hard to finish. The developer says the new material will tolerate 50 times more contamination than other black oxide finishing compounds. **KEY NO. 648**

▸ An air drying epoxy-acrylic coating for metals has been introduced by Industrial Finishes Co., 1119 Land Title Bldg., Broad & Chestnut Sts., Philadelphia 10. The coating, called EP-ACK, will not discolor when exposed to sunlight. It is said to resist acids, salt spray and humidity. **KEY NO. 649**

### Testing equipment

▸ Hardness of small plastics and rubber parts can be measured quickly and accurately on a new microhardness tester in which depth of penetration is measured electronically. The device, sold by Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y., is said to give accurate readings on parts less than 0.02 in. thick. **KEY NO. 650**

For more information, turn to Reader Service card, circle No. 436

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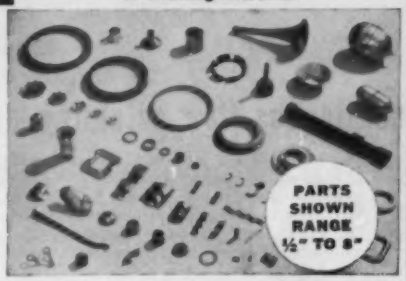


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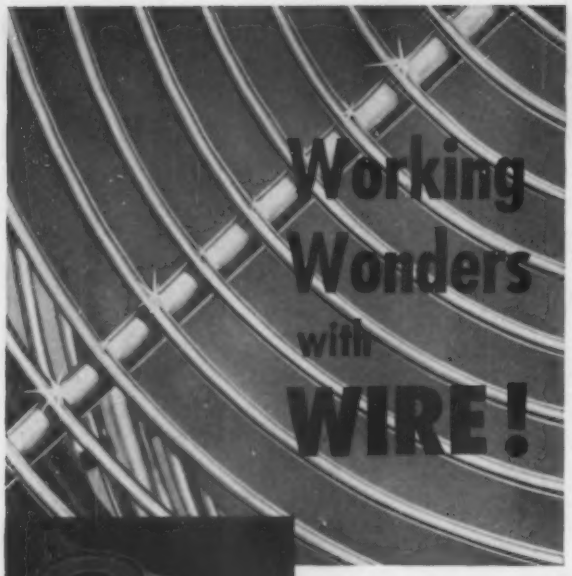

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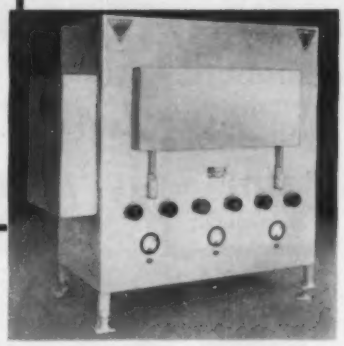

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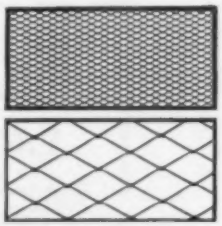

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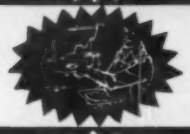

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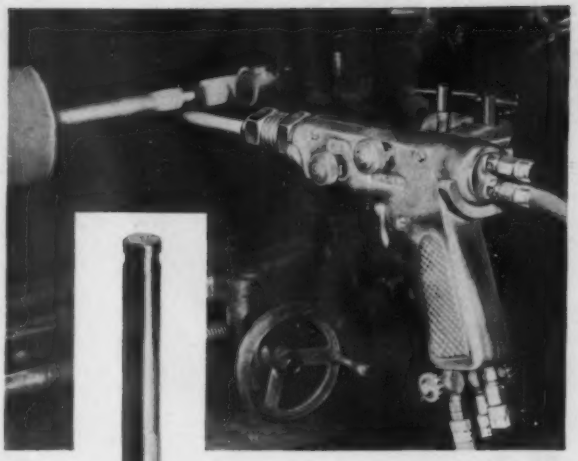

Above: A valve, with its ends protected by masks, receives a sprayed overlay of Colmonoy No. 6 hard-surfacing alloy. Left: A finished valve with long-wearing Colmonoy alloy stem surface.

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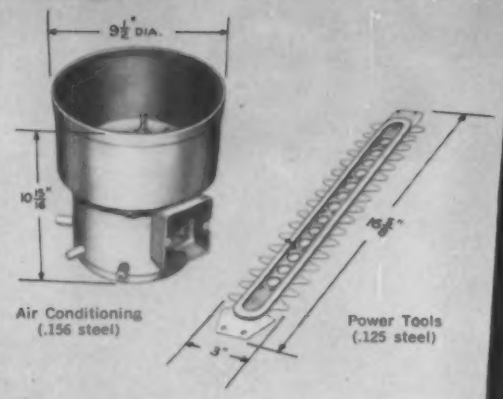


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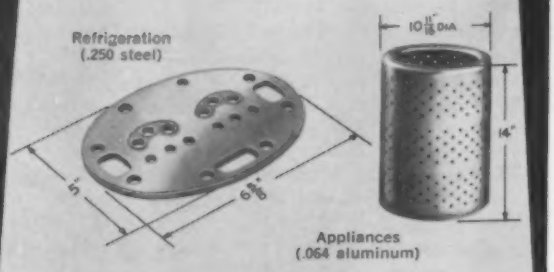


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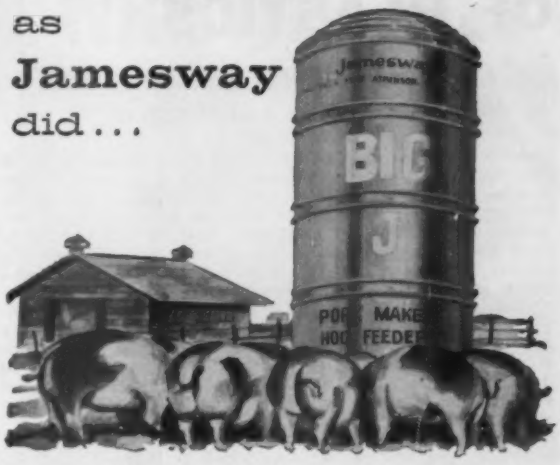


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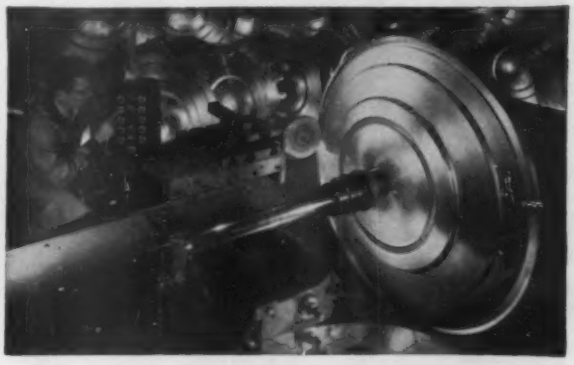

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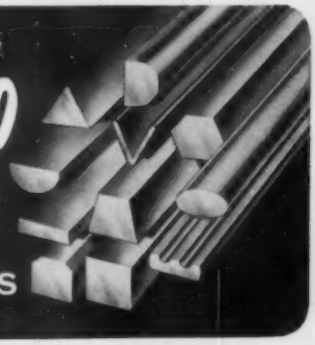

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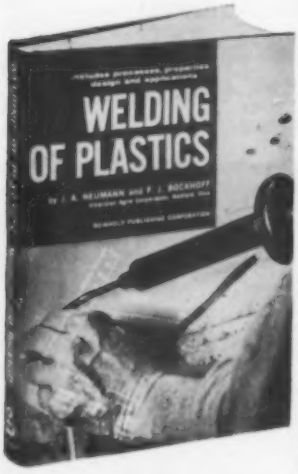


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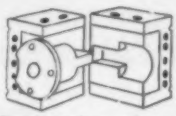

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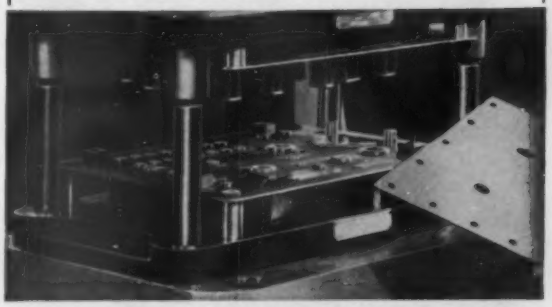

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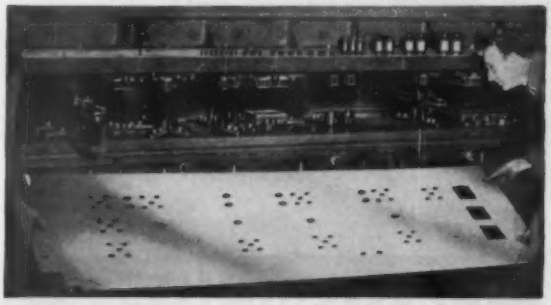

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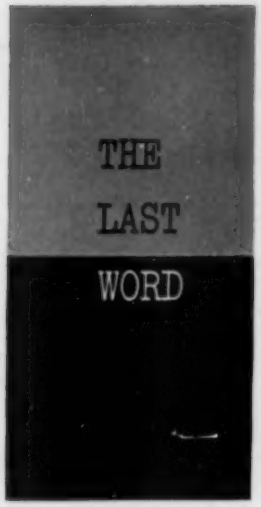


# Is That Technical Meeting Really Necessary?

*by H. R. Clauser*
*Editor*

How many times have you come away from a technical meeting disappointed because you had heard at least some of the papers somewhere before?

**Duplication is common**

From comments received, it is evident that more and more technical people are having this experience. A well-known authority in the high temperature field remarked recently that over a period of about eight months he will be attending meetings and symposiums on refractory materials sponsored by six different organizations. Even though he knows that many of the papers will be repeated, still he is obliged to attend all of the meetings on the off-chance that some new information will be disclosed.

Similarly, basic materials science has become a popular meeting topic in the last few years, and it seems as though some societies have proceeded with almost frantic haste to stake out their claim in the field by sponsoring programs on the subject. The result has been duplication of effort, and in a few cases the papers failed by a wide margin to fit the audience.

**Meetings are expensive**

A recent study sponsored by the Guggenheim Foundation gives some facts on the number and high cost of technical society meetings in the flight sciences field. The report, prepared by Pendray & Co., states that during each of the past three years eight major organizations held 35 to 43 meetings. Total cost each year: at least 258,000 man-days and $21,500,000. A survey of companies in the field showed that two out of three felt that there were too many meetings and that there was too much overlapping and duplication.

If other fields of engineering activity were surveyed, the findings probably would be about the same.

**Three ways societies could help**

What can be done to reduce the number of meetings and this duplication of effort?

For one thing, the societies could help a great deal by defining more specifically the scope of their objectives and activities, and then only plan meetings that fall within their sphere. They could also improve the situation by insisting on higher quality and by refusing papers that had been presented elsewhere or that consist largely of commercial "pap."

Joint meetings between two or more societies is another way to reduce duplication. Thus, in areas where objectives overlap, it is far better for societies to get together and sponsor one meeting than for each society to hold an independent one. Joint meetings not only save time but also encourage beneficial cross-fertilization of ideas.

**Central roster of meetings is needed**

Finally, to encourage more joint meetings, there should be a central agency to maintain a complete roster of technical society meetings and, if possible, to provide the necessary liaison to bring together societies with similar meeting plans. It would seem that the Engineers Joint Council would be the logical agency to perform such a service.

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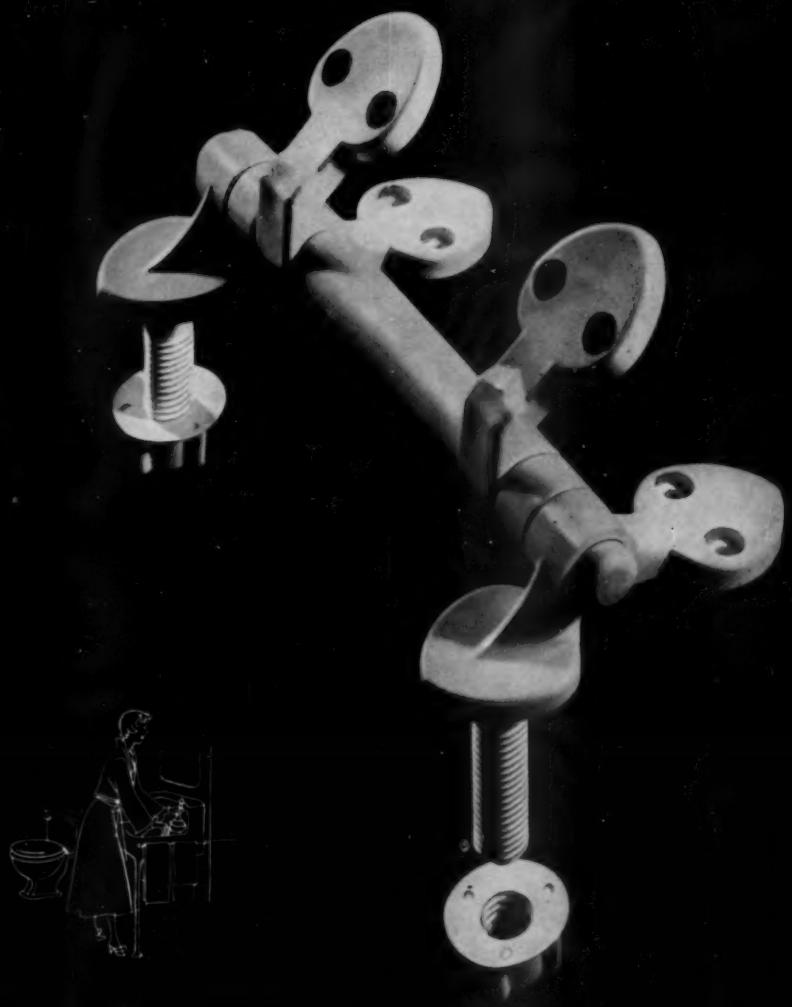

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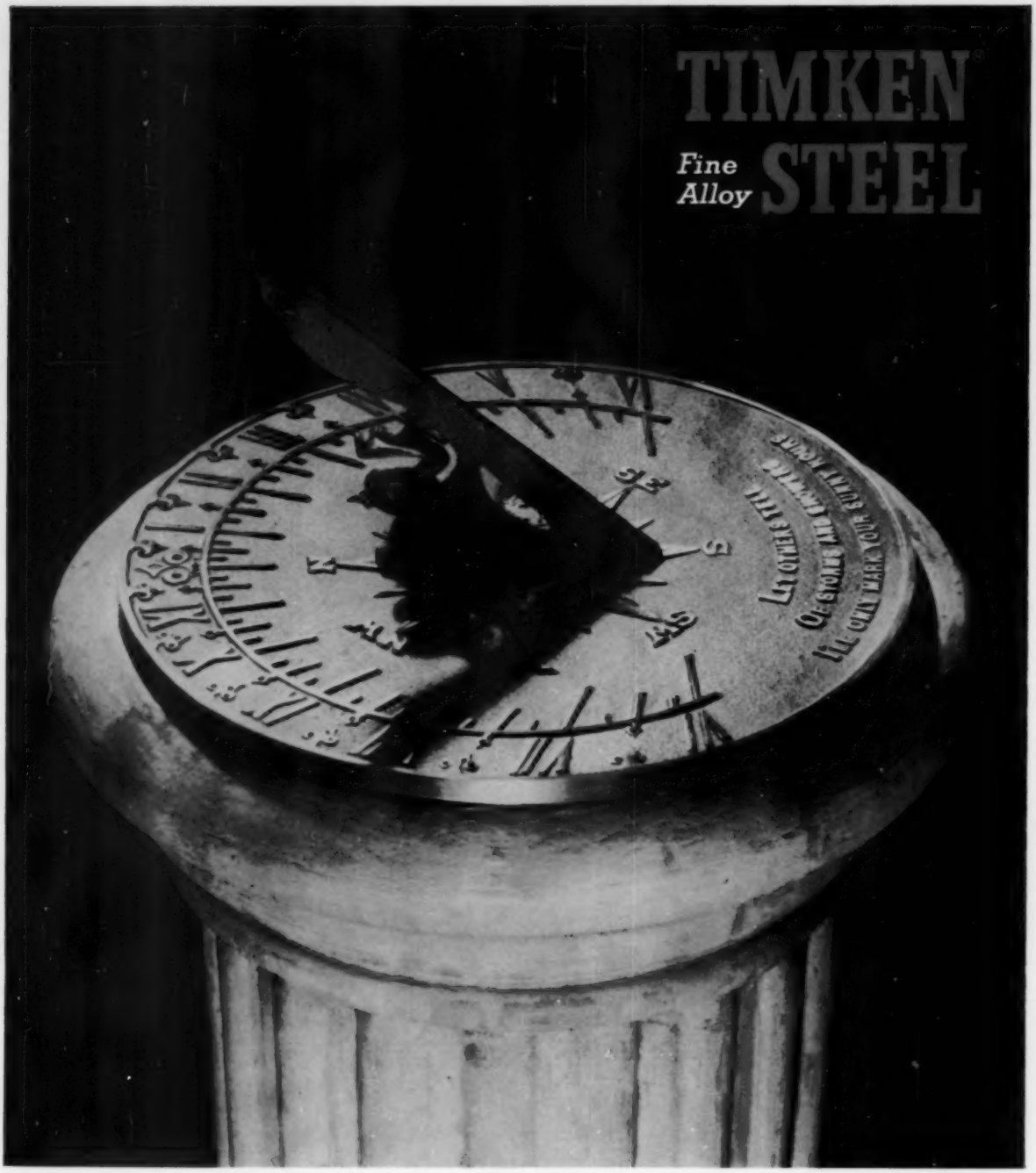


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